8EHQ-0893-12032

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Chevron

Chevron

93 AUG

Refining
P. O. Box 701
Port Arthur, TX 77641-0701

August 5, 1993

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

A

Document Process Center
Chemical Information Division
Office of Toxic Substances
U.S. Environmental Protection Agency
401 M Street S.W.
Washington, DC 20460

Attn: TSCA 8(e) Coordinator

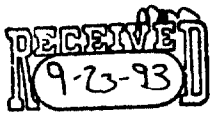
Dear Sir or Madam:

Re: TSCA 8(e) Submittal

Chevron U.S.A. Products Company, a division of Chevron U.S.A. Inc., is submitting this notice pursuant to Section 8(e) of the Toxic Substances Control Act (TSCA). This submittal relates to crude oil refining and petrochemical processes at the Chevron Port Arthur Refinery which is located on Highway 87 in Port Arthur, Texas.

Chevron's Medical Department is currently updating a mortality study through the end of 1987 among all Refinery employees, both hourly and salaried, who worked at the Refinery between 1937 and 1983. A preliminary analysis of the major cell type-specific cancers of the lymphatic and hematopoietic system indicated a statistically significant increase in deaths from acute lymphatic leukemia (ALL) among white male employees. This finding is based on eight death certificate reports of ALL as the underlying cause of death, where 2.6 would be expected using rates from the general U.S. white male population. In contrast, as Table 1 shows, no increase was observed for acute myeloid leukemia (AML), chronic myeloid leukemia (CML), non-Hodgkin's lymphoma (NHL), or multiple myeloma (MM); and a statistically significant deficit was shown for chronic lymphatic leukemia (CLL). To the best of our knowledge and belief, this is the first time an increase in ALL specifically has been reported in an epidemiologic study of workers in a petroleum refinery/petrochemical complex. This finding came to our attention on July 16, 1993.

In addition to the lack of support from other petroleum refinery studies, the increase in ALL is unusual for several reasons. First, we know of no epidemiological evidence of an increased incidence of ALL among benzene workers or other petroleum workers. Furthermore, the increase in deaths attributed to ALL may be due in part, or entirely, to a possible regional bias for diagnosing or classifying ALL as the cause of death for most lymphatic leukemias. This would likewise explain the significant decrease in CLL. We plan to further explore this. It is important to point out, too, that among the eight ALL deaths reported, all were hired before



3 DAS-

1954 (most before 1946). Also, seven of the eight either died, terminated employment, or retired prior to 1960. Therefore, whatever the cause or reason for the apparent excess in ALL deaths, it does not appear to involve employees hired after the early 1950's.

Additional investigation and analyses of these data are currently underway. For example, we have not yet determined if the employees reported to have died from ALL shared a common job type or like exposure, or whether the increased rate is related to length of employment or the interval since hire--factors which are important to the interpretation of this finding. Thus, by itself, the increase in ALL should not be interpreted as establishing a causal relationship between possible chemical exposures at the refinery and this cancer based on accepted epidemiologic criteria.

Over fifty other causes of death, including total leukemia deaths (AML, CML, ALL, CLL, plus other and unspecified forms of leukemia) will be analyzed. (The analyses performed to date are based on a statistical program which only examines the cell type-specific leukemias/lymphomas presented in Table 1.) A full report will be completed and submitted by the end of the year.

If you have any questions, please contact Dr. Kenneth Satin (Coordinator, Epidemiology and Biostatistics), Chevron Corporation, Medical Department, 225 Bush Street, Room 1359, San Francisco, CA 94104 (telephone 415/894-1718).

Very truly yours,

L. A. Gyorfi
Refinery General Manager

MLT:jsr

Attachment

TABLE 1

SUMMARY OF PORT ARTHUR WHITE MALE DEATHS DUE TO CANCER OF LYMPHATIC AND HEMATOPOIETIC TISSUE SMRs BY CELL TYPE

PORT ARTHUR REFINERY COHORT STUDY 1987 UPDATE

	Observed	Expected	SMR	95% Confidence Limits
AML (205.0)*	10	13.332	0.75	(0.36 - 1.38)
CML (205.1)	6	5.951	1.01	(0.37 - 2.19)
ALL (204.0)	8	2.589	3.09	(1.33 - 6.09)**
CLL (204.1)	2	8.380	0.24	(0.03 - 0.86)**
NHL (200,202)	26	35.267	0.74	(0.48 - 1.08)
MM (203)	12	16.163	0.74	(0.38 - 1.30)

AML = Acute Myeloid Leukemia
CML = Chronic Myeloid Leukemia
ALL = Acute Lymphatic Leukemia
CLL = Chronic Lymphatic Leukemia
NHL = Non-Hodgkin's Lymphoma
MM = Multiple Myeloma

* International Classification of Diseases (ICD), 8th Revision

** $P < 0.05$

CICATS DATA:
Submission # 8EHQ-0893-12032 SEQ. A

TYPE: (INT.) SUPP FLWP

SUBMITTER NAME: Chevron Corporation

SUB. DATE: 08/05/93 OTS DATE: 08/11/93 CSRAD DATE: 09/23/93

INFORMATION REQUESTED: FLWP DATE:
0501 NO INFO REQUESTED
0502 INFO REQUESTED (TECH)
0503 INFO REQUESTED (VOL ACTIONS)
0504 INFO REQUESTED (REPORTING RATIONALE)

DISPOSITION:
(0 3) REFER TO CHEMICAL SCREENING
0678 CAP NOTICE

VOLUNTARY ACTIONS:
0401 NO ACTION REPORTED
(0402) STUDIES PLANNED/UNDERWAY
0403 NOTIFICATION OF WORKER/CONSUMERS
0404 LABEL/MSDS CHANGES
0405 PROCESS/HANDLING CHANGES
0406 APP/USE DISCONTINUED
0407 PRODUCTION DISCONTINUED
0408 CONFIDENTIAL

CHEMICAL NAME: Petroleum Refining process

CAS# None

INFORMATION TYPE:		P F C
(0201)	ONCO (HUMAN)	01 02 04
0202	ONCO (ANIMAL)	01 02 04
0203	CELL TRANS (IN VITRO)	01 02 04
0204	MUTA (IN VITRO)	01 02 04
0205	MUTA (IN VIVO)	01 02 04
0206	REPRO/TERATO (HUMAN)	01 02 04
0207	REPRO/TERATO (ANIMAL)	01 02 04
0208	NEURO (HUMAN)	01 02 04
0209	NEURO (ANIMAL)	01 02 04
0210	ACUTE TOX. (HUMAN)	01 02 04
0211	CHR. TOX. (HUMAN)	01 02 04
0212	ACUTE TOX. (ANIMAL)	01 02 04
0213	SUB ACUTE TOX (ANIMAL)	01 02 04
0214	SUB CHRONIC TOX (ANIMAL)	01 02 04
0215	CHRONIC TOX (ANIMAL)	01 02 04

INFORMATION TYPE:		P F C
(0216)	EPI/CLIN	01 02 04
0218	HUMAN EXPOS (PROD CONTAM)	01 02 04
0218	HUMAN EXPOS (ACCIDENTAL)	01 02 04
0219	HUMAN EXPOS (MONITORING)	01 02 04
0220	BCO/AQUA TOX	01 02 04
0221	ENV. OCCC/REL/FATE	01 02 04
0222	EMER INCI OF ENV CONTAM	01 02 04
0223	RESPONSE REQEST DELAY	01 02 04
0224	PROD/COMP/CHEM ID	01 02 04
0225	REPORTING RATIONALE	01 02 04
0226	CONFIDENTIAL	01 02 04
0227	ALLERG (HUMAN)	01 02 04
022	ALLERG (ANIMAL)	01 02 04
022	METAB/PHARMACO (ANIMAL)	01 02 04
0246	METAB/PHARMACO (HUMAN)	01 02 04

INFORMATION TYPE:		P F C
0241	IMMUNO (ANIMAL)	01 02 04
0242	IMMUNO (HUMAN)	01 02 04
0243	CHEM/PHYS PROP	01 02 04
0244	CLASTO (IN VITRO)	01 02 04
0245	CLASTO (ANIMAL)	01 02 04
0246	CLASTO (HUMAN)	01 02 04
0247	DNA DAM/REPAIR	01 02 04
0248	PROD/USE/PROC	01 02 04
0251	MSDS	01 02 04
0299	OTHER	

TRIAGE DATA:

NON-CBI INVENTORY	ONGOING REVIEW	SPECIES	TOXICOLOGICAL CONCERN:	USE:	PRODUCTION:
YES (CONTINUE)	YES (DROP/REFER)	HUMN	LOW		
NO (DROP)	NO (CONTINUE)		MED		
(DETERMINE)	REFER:		HIGH		

COMMENTS: Non-CAP

Triage of 8(e) Submissions

Date sent to triage: JUN 15 1994

(NON-CAP) CAP

Submission number: 12032

TSCA Inventory: Y N (D)

Study type (circle appropriate):

Group 1 - Dick Clements (1 copy total)

ECO AQUATO

Group 2 - Erne Falke (1 copy total)

ATOX SBTOX SEN w/NEUR

Group 3 - Elizabeth Margosches (1 copy each)

STOX CTOX/ONCO CTOX RTOX GTOX

NEUR (EPI) IMMUNO CYTO

Other (FATE, EXPO, MET, etc.): _____

Notes:

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entire document: 1 2 3 **pages** _____ **pages** _____

Notes:

Contractor reviewer : _____ **Date:** _____

** CHEVRON **

to SAIC

SAES Ratings on Epidemiology 8(E) Submissions--August 5, 1993

8E Number & Chemical Name	Rank	Reason or Brief Description
12032 Benzene, petroleum & other crude refining oils	High	The submission (8EHQ-0893-12032) consists of: a letter from a representative of Chevron U.S.A., Inc. describing preliminary results of a mortality update among refinery workers (Port Arthur refinery cohort study[1]). The investigators analysis for type-specific lymphatic and hematopoietic cancers among refinery workers shows a statistically significant increase in acute lymphatic leukemia, a cancer type, they claim, has not previously been associated with benzene and other petroleum products. The Agency, having regulated benzene, should consider these findings of interest. We reserve any further comments, however, for the final study results (promised in early 1994).

[1] A brief literature search suggests the current study is a follow-up to Wongsrichanalai, C.; Delzell, E.; Cole, P. 1989. Mortality from leukemia and other disease among workers at a petroleum refinery. J. Occ. Med. 31(2):106-111.

Chevron

8EHQ-0194-12032

December 23, 1993

B
Contains No CBI

Chevron Corporation
575 Market Street, Room 1512
San Francisco, CA 94105

Kenneth P. Satin, Dr.P.H.
Coordinator, Epidemiology & Biostatistics
Medical Staff
Phone 415 894 1718
FAX 415 894 7669

Document Process Center
Chemical Information Division
Office of Toxic Substances
U.S. Environmental Protection Agency
401 M Street S.W.
Washington, DC 20460

Attn: TSCA 8(e) Coordinator

Dear Sir or Madam:

PDCN: 89[illegible]

On August 5 of this year, Chevron U.S.A. Products Company submitted a notice pursuant to Section 8(e) of the Toxic Substances Control Act. The submittal was related to a preliminary finding of increased acute lymphatic leukemia mortality among former employees of the Chevron Port Arthur Refinery which is located on Highway 87 in Port Arthur, Texas.

In that submittal, Mr. Gyorfi, the refinery manager, indicated a full report would be completed and submitted to your agency by the end of the year. I am writing to inform you that the report is not yet finished. However, additional analyses of the Port Arthur employee cohort have not revealed any new 8(e) reportable information.

I anticipate completing the report during the first quarter of 1994. A copy will be sent to you at that time.

If you have any questions, please contact me.

Sincerely,

Kenneth P. Satin, DrPH

CECATS\TRIAGE TRACKING DBASE ENTRY FORM

TPCATS DATA
submission # 8EH2-0194-12032 SEQ B

TYPE: INT (SUPP) FLWP

SUBMITTER NAME: Chevron Corporation

INFORMATION REQUESTED: FLWP DATE:
0501 NO INFO REQUESTED
0502 INFO REQUESTED (TECH)
0503 INFO REQUESTED (VOL ACTIONS)
0504 INFO REQUESTED (REPORTING RATIONALE)

DISPOSITION:
0639 REFER TO CHEMICAL SCREENING
0678 CAP NOTICE

VOLUNTARY ACTIONS:
0401 NO ACTION REPORTED
(0402) STUDIES PLANNED/UNDERWAY
0403 NOTIFICATION OF WORKER/OTHERS
0404 LABEL/MSDS CHANGES
0405 PROCESS/HANDLING CHANGES
0406 APP./USE DISCONTINUED
0407 PRODUCTION DISCONTINUED
0408 CONFIDENTIAL

SUB DATE: 12/23/93 OTS DATE: 01/05/94 CSB DATE: 01/21/94

CHEMICAL NAME: Petroleum Refining Process

CAS#: none

INFORMATION TYPE:		P	F	C
[redacted]	ONCO (HUMAN)	01	02	04
0202	ONCO (ANIMAL)	01	02	04
0203	CELL TRANS (IN VITRO)	01	02	04
0204	MUTA (IN VITRO)	01	02	04
0205	MUTA (IN VIVO)	01	02	04
0206	REPRO/TERATO (HUMAN)	01	02	04
0207	REPRO/TERATO (ANIMAL)	01	02	04
0208	NEURO (HUMAN)	01	02	04
0209	NEURO (ANIMAL)	01	02	04
0210	ACUTE TOX. (HUMAN)	01	02	04
0211	CHR. TOX. (HUMAN)	01	02	04
0212	ACUTE TOX. (ANIMAL)	01	02	04
0213	SUB ACUTE TOX (ANIMAL)	01	02	04
0214	SUB CHRONIC TOX (ANIMAL)	01	02	04
0215	CHRONIC TOX (ANIMAL)	01	02	04

INFORMATION TYPE:		P	F	C
[redacted]	EPI/CLIN	01	02	04
0217	HUMAN EXPOS (PROD CONTAM)	01	02	04
0218	HUMAN EXPOS (ACCIDENTAL)	01	02	04
0219	HUMAN EXPOS (MONITORING)	01	02	04
0220	ECO/AQUA TOX	01	02	04
0221	ENV. OCCC/REL/FATE	01	02	04
0222	EMER INCI OF ENV CONTAM	01	02	04
0223	RESPONSE REQEST DELAY	01	02	04
0224	PROD/COMP/CHEM ID	01	02	04
(0225)	REPORTING RATIONALE	01	02	04
0226	CONFIDENTIAL	01	02	04
0227	ALLERG (HUMAN)	01	02	04
0228	ALLERG (ANIMAL)	01	02	04
0239	METAB/PHARMACO (ANIMAL)	01	02	04
0240	METAB/PHARMACO (HUMAN)	01	02	04

INFORMATION TYPE:		P	F	C
0241	IMMUNO (ANIMAL)	01	02	04
0242	IMMUNO (HUMAN)	01	02	04
0243	CHEM/PHYS PROP	01	02	04
0244	CLASTO (IN VITRO)	01	02	04
0245	CLASTO (ANIMAL)	01	02	04
0246	CLASTO (HUMAN)	01	02	04
0247	DNA DAM/REPAIR	01	02	04
0248	PROD/USE/PROC	01	02	04
0251	MSDS	01	02	04
0299	OTHER	01	02	04

TRIAGE DATA:	NON-CBI INVENTORY	ONGOING REVIEW	SPECIES	TOXICOLOGICAL CONCERN:	USE:	PRODUCTION:
	YES (CONTINUE)	YES (DROP/REFER)	HmN	LOW		
	NO (DROP)	NO (CONTINUE)		MED		
	(DETERMINE)	REFER:		HIGH		

COMMENTS: Non-CAP

PDCN: 88930000404

94 NOV -2 AM 8:23

8EHQ-1194-12032

Chevron

Refining
P. O. Box 701
Port Arthur, TX 77641-0701

October 27, 1994

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

8EHQ-93-12032
SP002 11/02/94

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Document Process Center
Chemical Information Division
Office of Toxic Substances
U.S. Environmental Protection Agency
401 M Street S.W.
Washington, DC 20460

Attn: TSCA 8(e) Coordinator

89950000031

Dear Sir or Madam:

Re: TSCA 8(e) Submittal

On August 5, 1993, Chevron U.S.A. Products Company submitted a notice pursuant to Section 8(e) of the Toxic Substances Control Act. The submittal was related to a preliminary finding of increased acute lymphatic leukemia mortality among former employees of the Chevron Port Arthur Refinery, which is located on Highway 87 in Port Arthur, Texas.

The full analysis and corresponding report on the mortality experience of employees at the Refinery are now complete. Although the increase for acute lymphatic leukemia (ALL) remains, we do not believe it is related to crude oil refining and petrochemical processes at the Port Arthur Refinery. The primary reasons for this are:

1) Neither benzene nor other potential petroleum refining exposures have been toxicologically associated with ALL.

2) Our additional analyses did not reveal any trend between ALL and increasing years of employment at the Refinery.

3) The possibility the finding is spurious due to acute and chronic forms of the disease having been misdiagnosed or misreported on death certificates (for example, we observed chronic lymphatic leukemia to be significantly below the expected level, and the combined acute and chronic lymphatic leukemias to occur at the expected level).

4) The fact that four of the eight ALL cases worked at the Port Arthur Refinery for only a short period, or began working there at a relatively late age, suggesting the likelihood that other exposures or factors may have played an important role in the occurrence of the ALL.

RECEIVED 11/14/94

We also reviewed job histories, but this did not provide any additional insight regarding possible occupational associations. Lastly, we observed that all the ALL deaths occurred in employees hired before 1954 (most were hired before 1946); thus, if the increase were related to employment at the Refinery, the responsible factor does not appear to involve employees hired after the early 1950's.

Other analyses performed as part of the study looked at about 60 causes of death. Stratifications by sex, race, length of employment, interval since date of hire, and/or period of hire were performed. Some of the results of these analyses, particularly in isolated substrata, showed statistically significant increases for some causes of death. However, in no case do we believe an individual result reasonably supports a conclusion that employment at the Port Arthur Refinery presents a substantial health risk.

The full report containing a discussion of these causes of death and our interpretation of the findings is enclosed. If you have any questions, please contact Kenneth Satin (Coordinator, Epidemiology and Biostatistics), Chevron Corporation, Medical Department, 575 Market Street, Room 1512, San Francisco, CA 94104 (telephone 415/894-1718).

Sincerely,

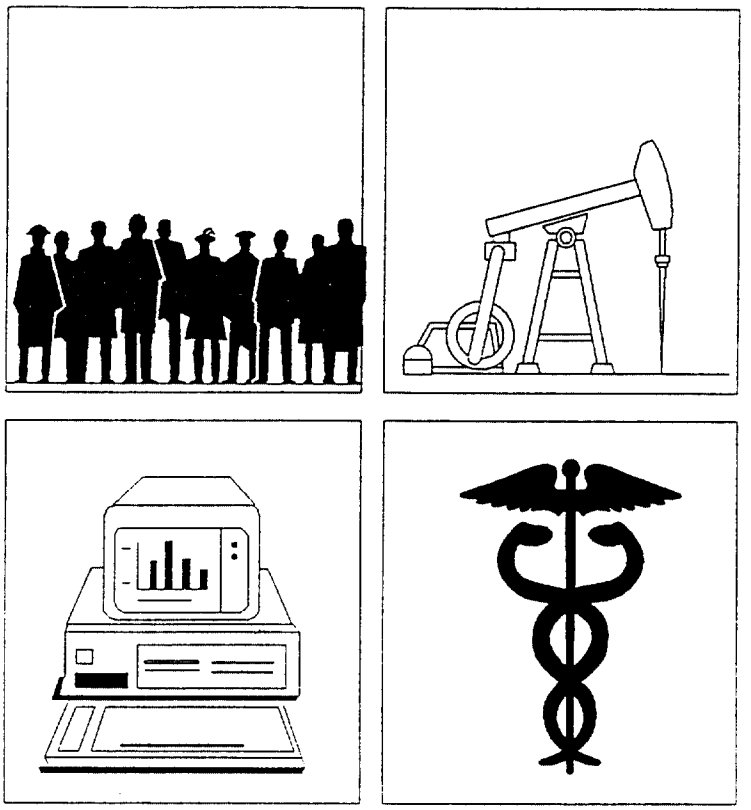
A. W. Weller
Refinery General Manager

KPS:jsr

Enclosure

Epidemiological Surveillance Report

An Updated Mortality Study of Chevron's Port Arthur Refinery, 1937-1987



Epidemiology and Biostatistics

Chevron Medical Staff

October 1994

TR94-016

AN UPDATED MORTALITY STUDY OF CHEVRON'S PORT ARTHUR REFINERY, 1937-1987

(TR94-016)

Kenneth P. Satin
Leslie A. Yuan
Otto Wong
William J. Bailey
Kimberly L. Newton
Chi-Pang Wen
Timothy G. Dagg
Laura L. Harmon

October 1994

ACKNOWLEDGMENT

The authors wish to thank Anita Ross for her work in coding and coordinating the quality assurance procedures for the causes of death. We also wish to thank Tom Mach, Diane Steeley, and Odessa Williams for their assistance in performing the cause of death quality assurance.

Table of Contents

EXECUTIVE SUMMARY

In 1980, the Gulf Oil Corporation began publishing a series of epidemiologic reports on the mortality of current and former employees working at the Port Arthur refinery. The Port Arthur study group consisted of more than 16,000 refinery workers, and their mortality experience was observed from 1937 to 1978. Subsequently, additional employees, who were hired after 1978 and worked for at least one day at the refinery, were enrolled in the study. The expanded cohort consists of 17,844 Gulf employees who had worked at the Port Arthur refinery anytime between January 1, 1937 and December 31, 1983. Following the merger of Gulf and Chevron in 1985, the data were transferred to the Medical Department at Chevron.

The vital status of the expanded cohort has been updated from the end of the original study period (December 31, 1978) through December 31, 1987. A total of 6,799 deaths were identified. Cause-specific standardized mortality ratios (SMRs) were calculated for the entire cohort as well as for various subcohorts. Cause-specific mortality data were also analyzed by length of employment, interval since hire, period of hire and pay status. Tests for trend were also performed.

In general, the results of the updated study demonstrated a favorable mortality experience for the Port Arthur employees as compared to the general populations of Texas or the United States. The overall mortality of the Port Arthur employees was about 7% less than the expected when compared to the Texas general population, and about 10% less than the expected when compared the U.S. general population.

More than 50 causes of death were examined, and 18 disease categories showed statistically significant deficits among the Port Arthur refinery workers. These categories included, among others, cancer of the biliary tract and liver, lymphosarcoma and reticulosarcoma, chronic lymphocytic leukemia, cerebrovascular disease, heart disease, non-

malignant respiratory disease, and external causes of death (e.g., accidents and injuries).

For many additional disease categories, mortality among the Port Arthur refinery employees was similar to that of the Texas general population. These categories included all cancers, cancer of the digestive organs, cancer of the respiratory system, prostate cancer, kidney cancer, bladder cancer, malignant melanoma of the skin, cancer of the central nervous system, non-Hodgkin's lymphoma, multiple myeloma, several types of leukemia, soft-tissue sarcoma, pulmonary fibrosis, and mesothelioma.

On the other hand, a few statistically significant mortality excesses were also found. As reported previously in the original study, a statistically significant excess of bone cancer was observed. However, no exposure-response relationship was evident from the length of employment analysis. As discussed in the original study, the bone cancer excess likely represented an artifact of the eighth revision of the International Classification of Diseases.

Mortality from benign brain tumor was border-line significant when compared to the Texas general population, but not to the U.S. general population. Analysis by length of employment did not reveal any exposure-response relationship. As such, it was unlikely that the border-line significant finding was related to employment at the refinery. Furthermore, for malignant tumors of the central nervous system (including brain cancer), the mortality of the Port Arthur refinery employees was similar to the expected.

Among the male employees, 8 deaths were coded as acute lymphocytic leukemia, whereas 3.08 deaths were expected. The resultant SMR of 259.6 was statistically significant. Conversely, mortality form chronic lymphocytic leukemia was significantly less than the expected (3 observed vs. 10.04 expected, SMR=29.9). Based on the length of employment analysis, no exposure-response relationship was detected for acute lymphocytic leukemia. Several possible explanations for the acute lymphocytic leukemia excess were offered, but no

definite conclusion could be made. No other refineries have reported an increase of acute lymphocytic leukemia. The excess of acute lymphocytic leukemia at the Port Arthur refinery was limited to employees hired before 1950.

In summary, the results of the updated study demonstrated a favorable mortality experience for the Port Arthur refinery employees as compared to the Texas general population or the U.S. general population. Most causes of death showed either a similar mortality or a significant deficit among the refinery employees when compared to the general population. Only a few causes of death showed statistically significant elevations. Further analyses by length of employment, trends over time, potential misclassification due to nosology rules, and likelihood of exposure given pay status job classifications did not support a conclusion that these increases resulted from employment at the refinery.

INTRODUCTION

In 1980, the Gulf Oil Corporation began publishing a series of epidemiologic reports on the mortality of current and former employees working at the Port Arthur refinery along the Texas Gulf Coast (Tabershaw Occupational Medicine Associates, 1980; Tsai et al., 1983; Wen et al., 1980, 1981a,b,c, 1983, 1984a,b,c,d, 1985, 1986). The Port Arthur cohort consisted of more than 16,000 refinery workers, and their mortality experience was observed from 1937 to 1978.

The results of these studies were generally favorable in that the overall mortality rate, and most cause-specific mortality rates, were lower than that of the general population. For the entire cohort, statistically significant deficits in mortality were observed for all causes, digestive cancer, esophageal cancer, rectal cancer, liver cancer, bladder cancer, lymphosarcoma and reticulosarcoma, heart disease, respiratory disease and several other non-malignant diseases. On the other hand, a statistically significant excess of bone cancer for the cohort was reported. However, a review of the actual causes of death of the cases indicated that the excess was likely an artifact stemming from the coding rules of the 8th revision of the International Classification of Diseases (ICD), which was used to code causes of death in the cohort.

The present study represents an update to the cohort of Port Arthur refinery employees. Ten additional years of follow-up have accrued since the original full cohort mortality assessment. The update should result in more precise estimates of mortality risk, and provide an opportunity for additional detailed analyses for some causes of death.

METHODS AND MATERIALS

The original cohort, as defined by Wen et al. (1980), consisted of employees who worked at least one day at the Port Arthur refinery between January 1, 1937 and January 1, 1978. Subsequently, additional employees, who were hired after 1978 and worked for at least one day at the refinery, were enrolled in the study (Wen et al., 1984a). Following the merger of Gulf and Chevron in 1985, the data were transferred to the Medical Department at Chevron. The vital status of the expanded cohort has been updated from the end of the original study period (December 31, 1978) through December 31, 1987.

As noted above, Gulf continued adding to the cohort employees who began working after 1978. Based on a review of the data, we concluded that 1983 was the last year new hires were systematically identified and included in the cohort. Thus, the expanded cohort consists of Gulf employees who had

worked at the Port Arthur refinery anytime between January 1, 1937 and December 31, 1983.

Sources for vital status determination of the expanded cohort included Gulf's personnel and annuitant record systems, the Texas Department of Motor Vehicles, the Social Security Administration, and the National Death Index. Detailed descriptions of methodological issues in the study are presented in a separate technical appendix. These issues include: study population enumeration, vital status update procedures, employment status update procedures, data quality review, and quality assurance procedures for cause of death coding.

The updated cohort consists of 17,844 individuals of which 6,799 had died as of the end of the study (December 31, 1987). For 347 deceased cohort members (5.1% of all deaths) no death certificates could be found, but the dates of death were known. These deaths were included only in the "all causes of death" category of the mortality analysis.

Mortality analysis was based on cause-specific standardized mortality ratios (SMRs), which are ratios of the number of observed deaths to the number of expected deaths. The number of expected deaths is calculated by applying mortality rates from a reference population to the person-years of observation in the cohort, and is adjusted for age, sex, calendar period and race. As the reference, we used general Texas population rates. We considered using the rates for the counties where most Port Arthur refinery employees live as a reference. However, because these county populations were relatively small, we felt their rates would be too variable (unstable) and thus unreliable to use as reference rates. Since most other refinery studies are based on a comparison to the U.S. general population, we also carried out one analysis for the entire cohort using the U.S. general population as the reference. The OCMAP program (Marsh and Preninger, 1980) was used to perform the mortality analyses.

Because of the *a priori* interest in cancers of the lymphatic and hematopoietic tissues and the previous leukemia cell-type analysis by Wen et al. (1984a), we conducted additional analyses for cell-type specific leukemias, non-Hodgkin's lymphoma, and multiple myeloma for the male cohort members. Age-specific leukemia cell-type mortality rates for U.S. white males for the period 1969-77 derived by Selvin et al. (1983) were used in the calculation. For non-Hodgkin's lymphoma and multiple myeloma, age-specific mortality rates for U.S. white males, 1950-1980, compiled by the National Cancer Institute were used (Pickle et al., 1987). Since no similar rates were available for non-white males, these rates were used for the entire male subcohort.

The following SMR analyses were performed on the cohort: total cohort, subcohorts stratified by sex and race, length of employment, interval since hire, period of hire, and pay status. The rationale for

these analyses is as follows. Length of employment serves as an indirect measure for potential refinery exposures. An increasing trend in mortality by length of employment supports an exposure-response relationship between refinery employment and mortality risk but, by itself, does not mean the relationship is necessarily one of cause and effect. Conversely, the absence of a trend (or a decreasing trend) argues against an association between work and the risk of death.

Interval since hire analysis follows from the observation that chronic diseases typically require a sufficiently long period (latency) after exposure to develop and become clinically apparent. In mortality studies, interval since hire is used as a surrogate for latency to permit examination of disease (mortality) in relation to the elapsed time since "exposure" first occurred.

With regard to period of hire, several investigators (Wen et al., 1986, Rinsky et al., 1981; Meinhardt et al., 1982; Bond et al., 1985) have reported adverse health effects for workers hired during the second world war period (approximately 1940-1945). They also reported that those hired before, after, or during the war years likely experienced different exposure intensities (e.g., higher before 1940 and lower after 1945) and exposure durations (e.g., longer before 1940 and shorter in the 1940 to 1945 period). These differences in exposure resulted from improved engineering controls and personal protective equipment, as well as lowering of regulatory exposure standards. Thus, stratification on period of hire provides a means of assessing time-related exposure risks.

Finally, analysis by pay status provides another indirect way to assess the effects of potential refinery exposures. The presumption here is that hourly employees were/are more likely to be exposed to higher concentrations of refinery chemicals than salaried workers due to the nature of their respective jobs.

Statistical tests for trend were conducted across length of employment strata using the method described by Breslow and Day (1987). The result of the trend test is expressed in terms of χ^2 with one degree of freedom (1 df).

RESULTS

Descriptive Statistics

The 17,844 cohort members accrued a total of 526,386.7 person-years of observation. Eighty-nine percent (12,608) of the cohort members are males and among them 79% are white (Table 1). Of the

females, nearly 89% are white. As of the end of the study period, 38% of the cohort was deceased. Death certificates were obtained for 95% of the decedents.

The duration of employment at the refinery ranged from 3 days to 54.6 years with the median duration being 12.4 years for males and 1.8 years for females (Table 2). Most cohort members have been followed for a considerable time. For males, the median interval since hire was 35.6 years while that for females was 31.9 years (Table 3).

Table 4 shows the distributions for age at death and year of death. The median age at death was 66.6 years. Approximately 60% of the deaths occurred in the 1970s and 1980s. Only 20% of the deaths were reported before 1950.

Mortality Analyses for the Total Cohort

Using Texas death rates as the reference, about 7% fewer deaths were observed than expected (Table 5). The resulting SMR, 92.7, was statistically significant[1]. Of the 56 cause of death categories analyzed, 17 additional categories showed statistically significant deficits. These categories include, among others, cancer of the biliary tract and liver, lymphosarcoma and reticulosarcoma, cerebrovascular disease, heart disease, non-malignant respiratory disease, and external causes of death (e.g., accidents and injuries).

On the other hand, a few significant mortality excesses were found. As reported previously in the original cohort, a significant SMR for bone cancer was observed (SMR=207.8, 95% CI: 110.6-355.3). A significant excess was also observed for the category "benign and unspecified neoplasms" (SMR=194.9, 95% CI: 129.5-281.7). Although many different sites are included in this category, 17 of the 28 deaths in this category involved the brain. In the U.S. general population, approximately 68% of the deaths in this broad category are brain tumors (Environmental Health Associates, 1983). Applying 68% to the expected number of 14.4 in Table 5, an estimate of 9.8 deaths from benign brain tumor could be expected. The corresponding SMR was estimated to be approximately 173.5 (17 observed/9.8 expected; 95% CI: 100.8-277.6), border-line significant.

Because of the use of asbestos at the refinery in the past, we also examined mortality from causes known to be associated with the substance. With respect to malignant diseases, asbestos is a known cause of both lung cancer and mesothelioma. Table 5 shows that lung cancer was not elevated

[1] Note: Throughout this report, "significant" means "statistically significant" and the two terms are used interchangeably.

(SMR=92.9, 95% CI: 83.4-101.2).

Regarding mesothelioma, the eighth revision of the ICD, used to code all deaths in the study, does not recognize a single code for this disease. Instead, depending on the wording on the death certificate, mesothelioma could be coded as a malignant respiratory cancer (ICD codes 162.1, 163, 163.0, or 163.9), a malignant neoplasm without specification of site (ICD codes 199, 199.0, or 199.1), or a benign respiratory disease (ICD codes 212.3, 212.4, or 228). Death certificates with any of these codes as either the underlying or contributing cause of death were manually reviewed to identify all mesotheliomas (malignant or benign). Six deaths were coded as a malignant mesothelioma. Age-specific malignant mesothelioma mortality rates were not available for either the general U.S. or Texas populations. However, since malignant mesothelioma is a rapidly fatal disease, national age-specific incidence rates for 1975-79 were used to estimate the expected number of malignant mesothelioma deaths (Connelly et al., 1987). These rates were derived from data in the SEER (Surveillance, Epidemiology, and End Results) Program, based on microscopically confirmed diagnoses. Mesotheliomas specified as benign were excluded from the SEER rates. For the Port Arthur cohort, 5.9 malignant mesothelioma deaths would have been expected. The resultant SMR was 101.7 (95% CI: 37.3-221.6) which was not statistically significant. In addition, 3 deaths were coded as benign mesothelioma. Benign or localized mesothelioma is not associated with exposure to asbestos (Antman and Corson, 1985; Briselli et al., 1981).

Asbestosis is the term for pulmonary fibrosis caused by exposure to asbestos, or, more correctly, in persons with a documented history of occupational exposure to asbestos. A thorough review of all death certificates in the study did not reveal any with the underlying cause of death as asbestosis (ICD 515.2), although ten deaths were due to pulmonary fibrosis (ICD 515.x - 517.x). These 10 deaths did not represent an increase in the occurence of generalized pulmonary fibrosis: the expected number of deaths in the study is 28.6 yielding an SMR of 35.0 (95% CI: 16.8-64.4). The expected number is based on unpublished data from the National Center for Health Statistics for the general U.S. population.

The analysis presented in Table 5 was based on mortality rates for Texas. Since most refinery studies are based on a comparison to the U.S. general population, an additional analysis for the entire cohort based on U.S. death rates was carried out (Table 6). In general, the results were similar to those based on Texas death rates. Several additional significant deficits were observed (e.g., cancer of digestive organs and peritoneum, esophageal cancer, rectal cancer, bladder cancer). Furthermore, the SMR for benign and unspecified neoplasms was no longer statistically significant. In particular, for benign brain tumor, the number of expected deaths was estimated to be 12.9, and the corresponding SMR was 131.7 (95% CI: 76.5-210.7). All other analyses in this report were based on Texas death rates, unless otherwise specified.

Mortality Analyses Stratified by Race and Sex

White males accounted for 71% of the entire cohort. Therefore, their mortality experience generally paralleled that of the entire cohort (Table 7). The overall SMR was significantly lower than expected (SMR= 96.6), while the same causes showing significantly elevated SMRs for the entire cohort, plus hypertension without heart disease (SMR=167.3), were also significantly elevated for the white males. A few additional significant mortality deficits were observed for white males, including cancer of digestive organs and peritoneum (SMR=86.5), esophageal cancer (SMR=51.6), bladder cancer (SMR=55.9), rectal cancer (SMR=59.8), and rheumatic heart disease (SMR=50.3).

The analysis for non-white males, based on 3,247 individuals and over 88,000 person-years of follow-up, also showed a significant deficit in overall mortality (SMR=78.4) (Table 8). No cause-specific SMRs were significantly elevated for non-white males. On the other hand, significant deficits were reported for cancer of the large intestine, lung cancer, all heart disease, non-malignant respiratory disease, and external causes of death.

Among the 1,778 white females in the cohort, 267 deaths were observed, yielding an SMR of 111.3, which was not statistically significant (Table 9). Two causes showed significant elevations: all malignant neoplasms (89 observed, SMR=126.5) and benign and unspecified neoplasms (4 observed, SMR=420.5). The increase in all malignant neoplasms was driven by cancers of the large intestine, lung, and breast. Although each of these showed an elevated SMR, none were statistically significant.

No analyses are presented for non-white females because only 10 deaths were observed among the 211 women in this subcohort. The causes of death were: malignant neoplasms (2), heart disease (3), non-malignant respiratory disease (1), external causes (1), and other causes (3). With so few deaths for any single cause of death category, death rates are unstable and comparisons to a reference population would not be meaningful.

Mortality Analyses by Length of Employment

Table 10 presents mortality analysis by length of employment for the entire cohort. Mortality from all causes combined showed a significantly decreasing trend by length of employment ($\chi^2_{trend\ (1\ df)}$=32.2, p=0.0000). Four cause-specific SMRs were significantly elevated in the 20-29 year stratum but no trend with length of employment was observed: stomach cancer (SMR=156.7; $\chi^2_{trend\ (1\ df)}$=0.49, p=0.4825), lymphatic and hematopoietic tissue (SMR=152.6; $\chi^2_{trend\ (1\ df)}$=0.49, p=0.4854), leukemia (SMR=222.7; $\chi^2_{trend\ (1\ df)}$=1.76, p=0.1840), and hypertension with heart disease (SMR=214.3; $\chi^2_{trend\ (1\ df)}$=3.23, p=0.0721). Three other cause-specific SMRs showed a significant excess in the 30+ year group

but only hypertension without heart disease demonstrated a positive trend: cervical cancer (SMR=888.6; n=3 observed deaths -- no trend test performed), benign and unspecified neoplasms (SMR=257.9; $\chi^2_{trend\,(1\,df)}$=1.25, p=0.2636) , and hypertension without heart disease (SMR=197.9; $\chi^2_{trend\,(1\,df)}$=9.95, p=0.0016).

Because bone cancer had a significantly elevated SMR in the entire cohort analysis, we performed a trend test on it as well even though no SMR in any of the strata was significantly elevated in the length of employment analysis. The result indicated no trend was present ($\chi^2_{trend\,(1\,df)}$=0.21, p=0.6473).

Length of employment analyses were also performed for the 3 major sex-race subcohorts (Tables 11-13). The results for white males (Table 11) paralleled those for the entire cohort although the category "all heart disease" revealed a significantly elevated SMR in the 10-19 year stratum. The trend test, however, was not significant ($\chi^2_{trend\,(1\,df)}$=0.07, p=0.7951). Among non-white males (Table 12), the SMR for kidney cancer was significantly elevated in the less than one year stratum which resulted in a significant inverse trend ($\chi^2_{trend\,(1\,df)}$=5.36, p=0.0206). Diabetes was also significantly elevated among non-white males in the 30 or more years stratum; this resulted in a positive trend ($\chi^2_{trend\,(1\,df)}$=4.89, p=0.0271). Because of the much smaller number of deaths for most other causes in the sex-race subcohorts, the length of employment analyses were not very informative.

Mortality Analyses by Interval Since Hire

Table 14 shows numerous cause of death categories, both cancers and non-cancers, with significant deficits in various intervals since hire. No significantly elevated SMRs were found for any cause in employees with an interval since hire less than 30 years. Several cause of death categories showed significantly elevated SMRs after at least a 30-year interval of time, but none had a positive trend with length of employment: all malignant neoplasms ($\chi^2_{trend\,(1\,df)}$=3.82, p=0.0506; borderline significant inverse trend), cancers of the stomach ($\chi^2_{trend\,(1\,df)}$=0.49, p=0.4825), central nervous system ($\chi^2_{trend\,(1\,df)}$=0.00, p=0.9873), bone ($\chi^2_{trend\,(1\,df)}$=0.21, p=0.6473), benign and unspecified neoplasms ($\chi^2_{trend\,(1\,df)}$=1.25, p=0.2636), hypertension with heart disease ($\chi^2_{trend\,(1\,df)}$=3.23, p=0.072), and suicides ($\chi^2_{trend\,(1\,df)}$=0.15, p=0.6965).

Subcohort analyses by interval since hire for white males yielded results similar to those of the entire cohort (Table 15). Among non-white males, significantly elevated SMRs were found for diabetes mellitus in the 40+ year stratum (Table 16), and a positive trend was seen with length of employment ($\chi^2_{trend\,(1\,df)}$=4.89, p=0.0271). In white females, the categories all causes, all malignant neoplasms, and cancer of the digestive organs and peritoneum had significantly elevated SMRs in the strata with at least 30 years since hire (Table 17). However, no trends with length of employment were seen (all causes: $\chi^2_{trend\,(1\,df)}$=0.01, p=0.9230; all malignant neoplasms: $\chi^2_{trend\,(1\,df)}$=0.23, p=0.6345; digestive cancers: $\chi^2_{trend\,(1}$

$_{df}$=0.11, p=0.7378). Cancer of the bladder and other urinary organs was also significantly elevated but this occurred only in the less than 10 years stratum and was based on a single death.

Mortality Analyses by Period of Hire

Table 18 shows that the total person-years of follow-up for the cohort were evenly spread across the three period-of-hire strata: before 1940, 1940 to 1945, and in or after 1945. The distribution of deaths, however, was skewed toward the earlier hire periods with more than half occurring in those hired prior to 1940. The table also shows that a higher percentage of women (18.5%) were hired in the 1940 to 1945 period (the war years) as compared to either the earlier period (3.2%) or the later period (8.9%). Across sex-race groups, employees hired in the 1940 to 1945 period worked at the refinery for a median of 0.9 year versus 30.7 years in the pre-1940 group and 8.3 years for those hired in or after 1945. Also, the median interval since hire (to the earliest of death, loss to follow-up, or the end of the study period) generally exceeded 40 years for cohort members hired prior to 1945. For those hired in or after 1945, the median interval since hire was 29.2, 16.1, and 17.3 years for white males, non-white males, and white females, respectively.

SMRs by period of hire are shown in Tables 19-22. For the entire cohort (Table 19), significant deficits in the all causes of death category were found for the before 1940 stratum (SMR=91.7) and the in or after 1945 stratum (SMR=77.7). The SMR (101.6) was close to expected for those hired between 1940 and 1945 (the war years). Fourteen and 13 additional causes of death showed significant deficits in the before 1940 and hired after 1945 strata, respectively. These compare to a total of 6 causes in the 1940 to 1945 stratum.

Three causes were significantly elevated in the before 1940 stratum: Hodgkin's disease (SMR=205.2), benign and unspecified neoplasms (SMR= 218.8), and hypertension without heart disease (SMR=145.9). None of these were significantly elevated in the other period of hire strata. No significantly elevated causes were found in the 1940 to 1945 stratum, while kidney cancer was the sole significantly increased cause of death among employees hired in or after 1945 (SMR=225.1).

The subcohort analysis by period of hire for white males is shown in Table 20. The results are similar to the before 1940 period except the increase in Hodgkin's disease is no longer significant. For the 1940 to 1945 group, the categories of all causes and pancreatic cancer were significantly elevated. No causes of death were significantly elevated among employees hired in or after 1945, although kidney cancer was greater than expected.

For non-white males significant SMR deficits were observed in all the period-of-hire strata

(Table 21). The only significantly elevated SMR was for Hodgkin's disease in the before 1940 stratum (SMR= 445.1).

Based on two deaths, the category benign/unspecified neoplasms was significantly elevated among white females hired in or after 1945 (Table 22). This was the only significant finding for the white female subcohort.

Mortality Analyses by Pay Status

The percentage of total time worked as a salaried employee was classified into one of seven categories: 0, 10, 25, 50, 75, 90, and 100 percent. The original designations made by Wen et al. (1983) were carried forward in the current update. Table 23 shows that 82.3% of the cohort members spent all their time as hourly employees, and they accounted for 87.2% of the deaths. On the other hand, only 12.7% of the cohort members spent at least 90% time of their employment as salaried employees, and they accounted for only 6.7% of the deaths. The pay status of 70 individuals (0.4%) was unknown, and they were excluded from the mortality analysis by pay status.

Three strata were formed for the mortality analysis: employment strictly hourly, employment at least 90% salaried, and all other combinations of hourly and salaried employment. The SMR results for the entire cohort by pay status are shown in Table 24. The overall SMR for each stratum was significantly less than 100, but the magnitude of the deficit increased with increasing time spent as a salaried worker. Hourly workers showed significantly elevated SMRs for the causes all malignant neoplasms (SMR=106.3) and bone cancer (SMR=228.7). Based on only four deaths, benign/unspecified neoplasms were significantly elevated in the mixed hourly-salaried group (SMR=433.1). Among salaried workers, significant elevations were found for the benign/unspecified neoplasms (SMR= 365.8) and hypertension without heart disease (SMR=375.7), but these were based on just a few deaths each: 5 and 8 deaths, respectively.

Analyses of Lymphatic and Hematopoietic Cancers

The set of rates we used in the OCMAP program does not provide analyses for cell-type specific leukemias, non-Hodgkin's lymphoma, or multiple myeloma. Therefore, separate analyses on these lymphatic and hematopoietic cancers for all males were carried out. There were non-significant deficits for acute myelogenous leukemia (SMR=62.7, 95% CI: 30.1-115.3), chronic myelogenous leukemia (SMR=84.4, 95% CI: 31.0-183.6), non-Hodgkin's lymphoma (SMR=71.0, 95% CI: 47.9-101.4), and multiple myeloma (SMR=98.0, 95% CI: 59.0-153.0) (Table 25). A significant excess was observed for acute lymphocytic leukemia (SMR=259.6, 95% CI: 112.1-511.5), whereas a significant deficit was

reported for chronic lymphocytic leukemia (SMR=29.9, 95% CI: 6.2-87.3).

All of the acute lymphocytic leukemia deaths occurred in white males who were hired prior to 1955 (Table 26). Two employees were older than 50 when they were hired at the refinery while two other employees worked at the refinery for less than 5 years (0.5 and 4, respectively). A trend analysis by length of employment for these deaths was also carried out. Because of the small number of deaths, only three categories were used. SMRs in all three categories were elevated, but no individual SMR was significant (Table 27). A formal test indicated that there was no positive trend by length of employment ($\chi^2_{\text{trend (1 df)}}=0.23$, p=0.6333).

DISCUSSION

Comparisons of this 1987 update of the Port Arthur Refinery cohort to earlier published reports indicated that the updated results were consistent with earlier ones published on the cohort. The cohort showed a generally more favorable mortality experience than the general population. For example, the cohort experienced significant mortality deficits from all causes combined, all heart diseases combined, non-malignant respiratory disease, and external causes.

Similar to the previous reports, bone cancer was significantly elevated for the cohort as a whole. A detailed discussion of the bone cancer excess can be found in two previous reports (Tabershaw Occupational Medicine Associates, 1980; Wen et al., 1983). A review of the actual causes listed on the death certificates indicated that several deaths were due to tumors of epithelial tissue (carcinomas) rather than sarcomas, i.e., they were not tumors of bone tissue (mesenchymal tissue) *per se*, but rather metastatic tumors from other sites (epithelial tissue). As such, these cancers reflect coding misclassifications derived from coding rules in the eighth revision of ICD, the basis for all cause of death coding in former and current mortality analyses. Had the ninth revision of the ICD been used instead, the bone tumors of epithelial origins would not have been considered primary bone cancers. Thus, the bone cancer excess can be considered an artifact stemming from the coding rules for the eighth revision of ICD codes. Furthermore, there was no exposure-response relationship between bone cancer and length of employment. This observation also argues against the bone cancer excess being occupationally related.

Most of the deaths in the significantly elevated benign/unspecified neoplasm category were benign brain tumors. The estimated SMR for benign brain tumor based on Texas death rates was border-

line significant (SMR=173.5, 95% CI: 100.8-277.6). Using the U.S. general population, the SMR was reduced to 131.7 (95% CI: 76.5-210.7), and was no longer statistically significant. Analysis by length of employment did not reveal any trend. For malignant tumors of the central nervous system, the observed number of deaths was similar to the expected, and the corresponding SMR (117.7) was not significant. In a previous report on brain tumors in the Port Arthur refinery cohort, Wen et al. (1981b) discussed the problems associated with diagnostic errors of brain tumors. Errors occur more frequently among inaccessible tumors such as those that occur in the liver, brain, or pancreas. Furthermore, liver and brain are two organs of the body known for their propensity of being metastatic cancer sites (Falk, 1982; Shoenberg, 1982). In fact, in the original study Wen et al. (1981b) identified 6 cases with likely incorrect diagnosis. A potential over-reporting of brain tumors in occupational groups as a result of diagnostic sensitivity bias has also been reported in several previous investigations (Greenwald et al., 1981; Wong et al., 1986; Wong and Whorton, 1993).

Our cell type analysis of leukemia deaths followed the previous work by Wen et al. (1984a), who reported no excess in myelogenous leukemia, but found elevated lymphocytic leukemias in employees who worked 20 to 29 years at the refinery. However, their analysis did not distinguish between acute and chronic lymphocytic leukemias. A comparable analysis in this update yielded no increase in either acute and chronic lymphocytic leukemias combined (11 observed deaths, 13.0 expected) or acute and chronic myelogenous leukemias combined (16 observed, 23.0 expected). However, a significant increase in acute lymphocytic leukemia (ALL) was found (SMR=259.6; 8 observed deaths, 3 expected). Conversely, the SMR for chronic lymphocytic leukemia (CLL) showed a significant deficit (SMR=29.9; 3 observed deaths, 10 expected).

The ALL excess coupled with a deficit of CLL could be important in the interpretation of these results. From a diagnostic perspective, historically it might have been difficult to distinguish between patients with CLL and those with ALL (Wintrobe et al., 1981). This difficulty would likely have prevailed during a large portion of the cohort follow-up period. The observations that half (26/52) of the leukemia death certificates for white males did not report the cell type (as was the case for 3 of the 4 leukemia deaths in non-white males), coupled with the fact that combined ALL and CLL death categories yielded an SMR not significantly different from expected (i.e., 100), lend some credence to the possibility of diagnostic difficulty and hence, misclassification with respect to recording the cause of death.

Further examination of the 8 ALL deaths revealed that 5 occurred in Jefferson County, Texas, while an additional two occurred in other Texas counties and one in California (Table 27). The observation that 5 of the 8 deaths occurred in the same Texas county also supports the possibility that the ALL increase is an artifact stemming from a local diagnostic bias. If even one ALL case was the result

of misdiagnosis, the ALL SMR would not have been statistically significant. In this regard it is noteworthy that one of the ALL death certificates listed the cause of death as "Alymphatic leukemia" [sic]. As this is not a generally recognized diagnosis, we sought outside advise on its meaning. Acute lymphocytic leukemia and acute myelogenous leukemia were the most common interpretations. Although strictly speaking we could not determine the cell type of this cancer, we nevertheless coded it as acute lymphocytic leukemia in our analysis.

We also examined the work histories for the ALL cases. However, because of the lack of specificity and nonstandardized way the information was recorded for cohort members during the early time periods covered by the study, no additional insight regarding possible occupational associations could be gleaned from this review.

Potential for exposure to benzene or benzene-containing mixtures exists at every petroleum refinery. Under conditions of high concentration and long duration, benzene is recognized as a human leukemogen. However, only acute myelogenous leukemia has been linked to benzene exposure. No epidemiologic study has demonstrated an association between exposure to benzene and acute lymphocytic leukemia. Similarly, no other petroleum refinery study has reported an increase of ALL (Wong and Raabe, 1994). Based on a meta-analysis of a combined cohort of more than 208,000 petroleum workers in the United Kingdom and the United States, including Port Arthur, the ALL SMR was 114 (95%: CI 78-161) (Wong and Raabe, 1994). Removing the Port Arthur data from the meta-analysis, the ALL SMR became 96. Thus, the finding from the Port Arthur refinery was not consistent with other studies of refinery workers with similar exposures.

The likely spurious nature of the ALL finding in the Port Arthur cohort is further supported by the lack of an exposure-response relationship based on length of employment analysis. In addition, with most of the deaths occurring in employees hired before 1950, acute lymphocytic leukemia does not appear to be a problem in more recently hired employees.

The objective of the length of employment analysis was to determine if there was a consistent upward trend in the exposure-response relationship, which we would consider important in our interpretation of potential causality. Hypertension without heart disease and diabetes were the only causes to show positive trends, but in neither case was the trend strictly increasing. Instead, each trend was solely due to an increase in the longest length of employment stratum while no trend was apparent across the other strata. In addition, the period of hire analysis showed that the increases in hypertension and diabetes were limited to employees hired prior to 1945. This suggests if occupational exposures did contribute to these deaths, the exposure is not affecting employees hired after 1945. Lastly, the increase in hypertension was also limited to salaried workers whose potential refinery exposures were likely to

have been briefer and less intense than hourly workers.

In general, several significant cause-specific mortality deficits as well as elevations were noted in individual length of employment strata. Apart from the two causes of death discussed above, no consistent pattern was detected for any cause of death, and the observed deficits as well as elevations were likely statistical artifacts. Because of the large number of SMRs calculated for various causes of death, length of employment categories and sex-race subcohorts, some of the SMRs might have been statistically significant as a result of chance. With the large number of strata, the number of deaths in some of the individual strata might be small, and the corresponding individual SMRs might not be reliable. As such, for length of employment analysis, only trends in the data and not individual SMRs were emphasized.

As in the length of employment analyses, several individual strata in the interval since hire analyses showed significant mortality deficits and elevations. Among causes with significant elevations, trend analyses with respect to length of employment, did not indicate the presence of positive trends with the exception of diabetes in non-white males. Diabetes is not generally associated with employment in the petroleum refining industry. For example, we found only a single report of a significant elevation (Rushton and Alderson, 1981). Lastly, the increase in the Port Arthur cohort was driven by employees hired prior to 1945 which suggests that employees hired during that time period might have had unusually high rates of intrinsic metabolic disorders.

In general, the interval since hire analyses, as well as those based on period of hire and pay status did not reveal any major new findings. These analyses were also affected by the same issues discussed above in conjunction with length of employment analysis. For period of hire, the updated results are in agreement with earlier accounts of the cohort (Wen et al., 1986) regarding differences among employees hired in the 1940 to 1945 period versus other times: women were more likely to be hired, employees tended to work at the refinery for a very short period, and overall, the healthy worker effect was not apparent. Primarily because of the short employment duration, significant elevations occurring only in the subcohort hired in the 1940 to 1945 period should not be given much weight, because for these employees, the opportunity for exposures was much greater outside of the Port Arthur refinery than while they were employed there.

Kidney cancer was the only significantly elevated cause of death among total cohort members hired after 1945 (12 observed, SMR=225.1) and ten of the twelve deaths occurred in persons hired between 1946 and 1951. This type of cancer has been the focus of considerable scientific research, both in animals and humans, stemming from an initial study which found an excess of kidney tumors in male rats following chronic exposure to wholly vaporized gasoline (MacFarland et al., 1984). Subsequent

toxicologic research has been critical of this finding's relevance to humans (Swenberg, 1993). Similarly, a recent review of the epidemiologic evidence found that most studies do not support a link between gasoline exposure and kidney cancer (McLaughlin, 1993). More specifically, several recently completed studies among petroleum refinery and distribution workers exposed to gasoline failed to identify a significantly increased risk for kidney cancer (Rushton, 1993; Schnatter et al., 1993; Wong et al., 1993; and Poole et al., 1993). These observations, together with the fact that no increase was found prior to 1945, suggested that kidney cancer deaths occurring between 1945 and 1951 most likely represented a random cluster, and were not related to employment at the refinery.

It should be pointed out that there were several limitations in the study, most of which are typical of historical cohort mortality studies of industrial populations. First, death certificates for 5% of the deaths identified could not be retrieved. While these deaths were included in the all causes combined analyses, some cause-specific SMRs might have been affected (underestimated) because of these missing death certificates. Second, the vital status of 6.5% of the males and 31.1% of the females in the cohort was unknown. This missing information might have affected some of the results, especially for women in the study. Third, being a mortality study, this investigation inherited the problems associated with death certificates (e.g., diagnostic accuracy, comparability of ICD codes over time). In particular, the use of the eighth revision of ICD was problematic in analyzing bone cancer. Fourth, some analyses were potentially affected by the limited availability of reference rates for comparison. For example, for specific lymphatic and hematopoietic cancers, rates for white males were used for all males. Furthermore, certain mortality rates were not available for the entire observation period. Fifth, although the Port Arthur refinery cohort was probably one of the largest data sets in the petroleum industry, for some causes, the number of deaths was relatively small. For these causes, some results might not be statistically stable or reliable. Finally, the interpretation of the results is limited by the absence of quantitative exposure data. Because of this, we relied on indirect measures of exposure: length of employment, period of hire, and pay status. Although this is a common practice in occupational epidemiologic studies, the use of surrogates may result in misclassifying employees with respect to possible exposures which could result in some SMRs being underestimated.

CONCLUSION

In summary, the results of the updated study demonstrated a favorable mortality experience for the Port Arthur refinery employees as compared to the Texas general population or the U.S. general population. Most causes of death showed either a similar mortality or a statistically significant deficit among the refinery employees when compared to the general population. Only a few causes of death

showed statistically significant elevations. Further analyses by length of employment, trends over time, potential misclassification due to nosology rules, and likelihood of exposure given pay status job classifications did not support a conclusion that these increases resulted from employment at the refinery.

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Table 1
Demographic and Vital Status Characteristics for All Cohort Members
Port Arthur Refinery Update, 1937–1987

	Male	Female	TOTAL
Population Size (%)	15855 (89)	1989 (11)	17844 (100)
Person–Years of Follow–up	474875	51512	526387
Year of Birth Distribution			
< 1900	15.5%	1.7	13.9
1900–1909	15.6	6.1	14.5
1910–1919	21.2	22.2	21.3
1920–1929	20.8	43.2	23.3
1930–1939	9.2	7.0	8.9
1940–1949	7.1	8.1	7.2
1950–1959	9.7	11.1	9.9
1960–1969	1.0	0.6	0.9
Age[1] Distribution			
Average	49.4 yrs	33.6	47.7
P_{50}	52.7	27.5	48.0
P_{95}	80.6	67.6	80.2
Range	16.4–104.7[2]	15.4–92.6	15.4–104.7
Race Distribution			
White			
White	79.0%	88.6	80.1
Assumed White	0.5	0.8	0.5
Non–White			
Black	17.0	5.8	15.7
Assumed Black	0.1	0.1	0.1
Hispanic	1.5	1.3	1.5
Native American	0.1	0.1	0.1
Asian	0.1	0.1	0.1
Unknown	1.7	3.3	1.9
Vital Status (as of 12/31/87)			
Alive	52.4%	55.0	52.7
Dead[3]	41.1	13.9	38.1
Unknown	6.5	31.1[4]	9.2

1 Age at earliest of: time of death, loss to follow–up, or end of study (13/31/87). Note: P_{50} refers to the 50th percentile (median) and P_{95} refers to the 95th percentile.

2 The dates used to calculate the age were verified for accuracy by checking against the hard copy work history and MEDIC. The dates were correct. There are males in the cohort who were born in the late 1800s and lived more than 100 years.

3 Death certificates obtained for 6455 (95%) decedents.

4 Of the women with an unknown vital status, over 88% had retired, terminated, or had been transferred on or before 12/31/60 making tracing nearly impossible. In fact, almost one–third were lost to follow–up during the period 1940–1945.

Table 2
Employment Characteristics for All Cohort Members
Port Arthur Refinery Update, 1937-1987

	Male (n=15855)	Female (n=1989)	TOTAL (n=17844)
Employment Duration			
< 1 year	22.2%	41.3	24.3
1-9	23.6	40.3	25.4
10-19	14.7	9.7	14.1
20-29	10.3	4.0	9.6
≥ 30	29.3	4.7	26.6
Average	16.7 yrs	5.8	15.5
P_{50}	12.4	1.8	10.2
P_{95}	41.3	29.2	40.8
Range	3 days-54.6 years[1]	3 days-44.7 years	3 days-54.6 years

[1]There are males in the cohort whose length of employment exceeded 50 years. The date of hire and the date of termination were checked for these males. The dates were correct according to personnel records.

Table 3
Time of Hire Characteristics for All Cohort Members
Port Arthur Refinery Update, 1937–1987

	Male(n=15855)	Female(n=1989)	TOTAL(n=17844)
Interval Since Hire[1]			
< 10 years	10.2%	29.6	12.3
10–19	15.5	11.3	15.0
20–29	9.9	6.5	9.5
30–39	24.6	16.0	23.6
≥ 40	39.8	36.7	39.5
Average	33.2 yrs	26.3	32.4
P_{50}	35.6	31.9	35.4
P_{95}	58.1	47.3	57.5
Range	3 days–77.5 years	3 days–72.0 years	3 days–77.5 years
Year of Hire			
1900–1909	0.5%	0.0	0.4
1910–1919	5.3	0.2	4.7
1920–1929	15.9	1.9	14.3
1930–1939	9.9	6.9	9.6
1940–1949	34.5	61.7	37.6
1950–1959	14.7	7.7	13.9
1960–1969	4.0	3.5	3.9
1970–1979	13.0	15.4	13.3
1980–1987	2.2	2.6	2.3
Age at Hire			
< 20 years	18.4%	32.7	20.0
20–29	59.7	51.7	58.8
30–39	16.7	12.9	16.2
40–49	4.4	2.4	4.2
≥ 50	0.8	0.3	0.8

[1]Interval since initial hire is the period between hire date and the earlier of date of death, date of last contact, or end of study.

Table 4
Time of Death Characteristics for All Cohort Members
Port Arthur Refinery Update, 1937-1987

	Male(n=6522)	Female(n=277)	TOTAL (n=6799)
Age at Death			
≤ 29 years	1.6%	1.1	1.6
30-39	3.5	4.7	3.5
40-49	8.3	11.2	8.4
50-59	18.6	23.1	18.8
60-69	27.7	30.3	27.8
≥ 70	40.2	29.6	39.8
Average Age (yrs)	65.3	62.9	65.2
P_{50}	66.7	63.5	66.6
Year of Death			
1930-1939	1.0%	0.4	1.0
1940-1949	6.8	1.4	6.6
1950-1959	12.9	6.5	12.6
1960-1969	21.0	9.4	20.5
1970-1979	31.0	30.0	31.0
1980-1987	27.3	52.3	28.3

Table 5
Cause Specific SMRs for ALL COHORT MEMBERS
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

No. of Persons at Risk = 17,844 Person–Years = 526,386.7

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Observed	Expected	SMR	95% Confidence Interval Lower	Upper
All Causes of Death	6799	7336.0	92.7 **	90.5	94.9
Tuberculosis	33	38.7	85.2	58.6	119.6
All Malignant Neoplasms	1482	1444.3	102.6	97.4	108.0
Cancer of Buccal Cavity & Pharynx	36	40.9	87.9	61.6	121.8
Cancer of Digestive Organs & Peritoneum	377	371.7	101.4	91.4	112.2
Cancer of Esophagus	23	34.1	67.5	42.8	101.3
Cancer of Stomach	95	80.2	118.5	95.9	144.9
Cancer of Large Intestine	117	106.4	110.0	90.9	131.8
Cancer of Rectum	26	26.3	98.8	64.5	144.8
Cancer of Biliary Passages & Liver	13	31.0	41.9 **	22.3	71.6
Cancer of Pancreas	94	80.8	116.4	94.1	142.4
Cancer of Respiratory System	448	485.5	92.3	83.9	101.2
Cancer of Bronchus, Trachea, Lung	423	459.8	92.0	83.4	101.2
Cancer of Breast	22	17.6	125.4	78.6	189.8
All Uterine Cancers (Females only)	7	6.7	104.2	41.9	214.7
Cancer of Cervix Uteri (Females only)	3	4.2	71.5	14.7	208.8
Cancer of Other Female Genital Organs	5	5.3	93.7	30.4	218.5
Cancer of Prostate (Males only)	126	131.0	96.2	80.1	114.5
Cancer of Testes and Other Male Genital Organs	5	6.3	79.0	25.6	184.3
Cancer of Kidney	40	31.3	127.9	91.4	174.2
Cancer of Bladder and Other Urinary Organs	25	34.8	71.9	46.5	106.1
Malignant Melanoma of Skin	21	18.7	112.2	69.5	171.5
Cancer of Eye	2	1.0	191.7	23.2	692.5
Cancer of Central Nervous System	39	33.1	117.7	83.7	160.9
Cancer of Thyroid & Other Endocrine Glands	7	4.6	151.3	60.8	311.8
Cancer of Bone	13	6.3	207.8 *	110.6	355.3
Cancer of All Lymphatic, Haematopoietic Tissue	138	131.7	104.8	88.0	123.8
Lymphosarcoma & Reticulosarcoma	13	23.0	56.5 *	30.1	96.5
Hodgkins Disease	18	12.7	141.3	83.7	223.3
Leukemia & Aleukemia	57	55.9	102.0	77.3	132.2
Cancer of All Other Lymphopoietic Tissue	50	40.1	124.7	92.6	164.5
Benign Neoplasms/Neoplasms of Unspecified Nature	28	14.4	194.9 **	129.5	281.7
Diabetes Mellitus	107	101.2	105.7	86.7	127.8
Cerebrovascular Disease	502	600.5	83.6 **	76.4	91.2
All Heart Disease	2534	2784.9	91.0 **	87.5	94.6
Rheumatic Heart Disease	32	36.7	87.1	59.6	123.0
Ischemic Heart Disease	1994	2283.3	87.3 **	83.5	91.2
Chronic Endocard. Dis.; Other Myocard. Insuff.	44	81.6	54.0 **	39.2	72.4
Hypertension with Heart Disease	72	63.7	113.0	88.4	142.3
Hypertension w/o Heart Disease	32	29.9	107.2	73.3	151.3
Non–malignant Respiratory Disease	346	469.4	73.7 **	66.1	81.9
Influenza & Pneumonia	132	199.7	66.1 **	55.3	78.4
Bronchitis, Emphysema, Asthma	101	137.8	73.3 **	59.7	89.1
Bronchitis	21	24.5	85.7	53.1	131.0
Emphysema	72	102.5	70.2 **	54.9	88.4
Asthma	8	10.7	74.8	32.3	147.4
Ulcer of Stomach & Duodenum	28	37.0	75.6	50.3	109.3
Cirrhosis of Liver	79	121.9	64.8 **	51.3	80.8
Nephritis & Nephrosis	50	51.6	96.9	71.9	127.7
All External Causes of Death	547	759.3	72.0 **	66.1	78.3
Accidents	367	467.9	78.4 **	70.6	86.9
Motor Vehicle Accidents	169	239.6	70.5 **	60.3	82.0
All Other Accidents	198	229.1	86.4 *	74.8	99.3
Suicides	111	118.2	93.9	77.2	113.1
Homicides & Other External Causes	69	137.8	50.1 **	39.0	63.4
All Other Causes of Death	684	833.1	82.1 **	76.1	88.5
Unknown Causes (In All Causes Category Only)	347				

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 6
Cause Specific SMRs for ALL COHORT MEMBERS
Port Arthur Refinery Update, 1937 – 1987
Expected Deaths Based on US DEATH RATES

No. of Persons at Risk = 17,844 Person – Years = 526,386.7

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Observed	Expected	SMR	95% Confidence Interval	
				Lower	Upper
All Causes of Death	6799	7541.1	90.2 **	88.0	92.3
Tuberculosis	33	41.3	79.9	55.0	112.2
All Malignant Neoplasms	1482	1528.6	97.0	92.1	102.0
Cancer of Buccal Cavity & Pharynx	36	45.0	80.0	56.0	110.8
Cancer of Digestive Organs & Peritoneum	377	435.9	86.5 **	78.0	95.7
Cancer of Esophagus	23	44.5	51.6 **	32.7	77.5
Cancer of Stomach	95	92.5	102.7	83.1	125.6
Cancer of Large Intestine	117	134.3	87.1	72.0	104.4
Cancer of Rectum	26	43.5	59.8 **	39.1	87.7
Cancer of Biliary Passages & Liver	13	26.6	48.8 **	26.0	83.4
Cancer of Pancreas	94	80.6	116.7	94.3	142.8
Cancer of Respiratory System	448	482.2	92.9	84.5	101.9
Cancer of Bronchus, Trachea, Lung	423	454.2	93.1	84.5	102.4
Cancer of Breast	22	21.0	104.8	65.7	158.7
All Uterine Cancers (Females only)	7	7.0	99.9	40.1	205.8
Cancer of Cervix Uteri (Females only)	3	4.2	70.9	14.6	207.2
Cancer of Other Female Genital Organs	5	6.4	78.7	25.5	183.6
Cancer of Prostate (Males only)	126	136.4	92.4	77.0	110.0
Cancer of Testes and Other Male Genital Organs	5	6.9	72.5	23.5	169.1
Cancer of Kidney	40	32.7	122.4	87.5	166.7
Cancer of Bladder and Other Urinary Organs	25	44.7	55.9 **	36.2	82.5
Malignant Melanoma of Skin	21	14.7	142.7	88.4	218.2
Cancer of Eye	2	1.1	175.3	21.2	633.3
Cancer of Central Nervous System	39	35.2	110.8	78.8	151.5
Cancer of Thyroid & Other Endocrine Glands	7	5.1	137.8	55.4	283.9
Cancer of Bone	13	6.6	198.4 *	105.6	339.3
Cancer of All Lymphatic, Haematopoietic Tissue	138	135.6	101.8	85.5	120.3
Lymphosarcoma & Reticulosarcoma	13	25.4	51.2 *	27.3	87.6
Hodgkins Disease	18	14.2	127.1	75.3	200.9
Leukemia & Aleukemia	57	55.0	103.7	78.6	134.4
Cancer of All Other Lymphopoietic Tissue	50	41.1	121.7	90.3	160.4
Benign Neoplasms/Neoplasms of Unspecified Nature	28	18.9	148.4	98.6	214.4
Diabetes Mellitus	107	115.9	92.3	75.7	111.6
Cerebrovascular Disease	502	584.4	85.9 **	78.6	93.8
All Heart Disease	2534	3008.5	84.2 **	81.0	87.6
Rheumatic Heart Disease	32	63.6	50.3 **	34.4	71.1
Ischemic Heart Disease	1994	2650.5	75.2 **	72.0	78.6
Chronic Endocard. Dis.; Other Myocard. Insuff.	44	62.2	70.8 *	51.4	95.0
Hypertension with Heart Disease	72	74.6	96.5	75.5	121.5
Hypertension w/o Heart Disease	32	32.5	98.3	67.3	138.8
Non – malignant Respiratory Disease	346	494.7	69.9 **	62.8	77.7
Influenza & Pneumonia	132	215.2	61.3 **	51.3	72.7
Bronchitis, Emphysema, Asthma	101	132.9	76.0 **	61.9	92.3
Bronchitis	21	21.9	96.0	59.4	146.8
Emphysema	72	98.5	73.1 **	57.2	92.1
Asthma	8	11.9	67.0	28.9	132.0
Ulcer of Stomach & Duodenum	28	45.2	61.9 **	41.2	89.5
Cirrhosis of Liver	79	160.5	49.2 **	39.0	61.3
Nephritis & Nephrosis	50	49.2	101.6	75.4	133.9
All External Causes of Death	547	657.8	83.2 **	76.3	90.4
Accidents	367	410.0	89.5 *	80.6	99.2
Motor Vehicle Accidents	169	190.3	88.8	75.9	103.3
All Other Accidents	198	220.0	90.0	77.9	103.4
Suicides	111	120.0	92.5	76.1	111.4
Homicides & Other External Causes	69	96.2	71.7 **	55.8	90.8
All Other Causes of Death	684	768.2	89.0 **	82.5	96.0
Unknown Causes (In All Causes Category Only)	347				

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 7
Cause Specific SMRs for WHITE MALES
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

No. of Persons at Risk = 12,608 Person–Years = 386,469.8

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Observed	Expected	SMR	95% Confidence Interval	
				Lower	Upper
All Causes of Death	5180	5362.4	96.6 *	94.0	99.3
Tuberculosis	22	26.0	84.5	53.0	128.0
All Malignant Neoplasms	1096	1045.5	104.8	98.7	111.2
Cancer of Buccal Cavity & Pharynx	27	31.1	86.9	57.3	126.4
Cancer of Digestive Organs & Peritoneum	271	258.4	104.9	92.8	118.2
Cancer of Esophagus	11	19.6	56.2	28.1	100.6
Cancer of Stomach	58	50.8	114.1	86.7	147.5
Cancer of Large Intestine	90	79.1	113.8	91.5	139.9
Cancer of Rectum	22	19.2	114.5	71.7	173.3
Cancer of Biliary Passages & Liver	10	21.2	47.3 *	22.7	86.9
Cancer of Pancreas	73	59.7	122.4	95.9	153.9
Cancer of Respiratory System	352	373.1	94.3	84.7	104.7
Cancer of Bronchus, Trachea, Lung	333	353.9	94.1	84.3	104.8
Cancer of Breast	0	1.1	---	0.0	327.1
All Uterine Cancers (Females only)	0	0.0	---	---	---
Cancer of Cervix Uteri (Females only)	0	0.0	---	---	---
Cancer of Other Female Genital Organs	0	0.0	---	---	---
Cancer of Prostate (Males only)	90	86.8	103.7	83.4	127.5
Cancer of Testes and Other Male Genital Organs	4	4.8	84.3	23.0	215.8
Cancer of Kidney	27	25.2	107.2	70.7	156.0
Cancer of Bladder and Other Urinary Organs	17	26.4	64.5	37.6	103.2
Malignant Melanoma of Skin	21	16.9	124.1	76.8	189.7
Cancer of Eye	2	0.9	219.8	26.6	794.0
Cancer of Central Nervous System	32	28.1	114.0	78.0	160.9
Cancer of Thyroid & Other Endocrine Glands	6	3.7	163.7	60.1	356.4
Cancer of Bone	10	4.6	217.2 *	104.1	399.4
Cancer of All Lymphatic, Haematopoietic Tissue	113	101.1	111.7	92.1	134.4
Lymphosarcoma & Reticulosarcoma	9	18.5	48.8 *	22.3	92.6
Hodgkins Disease	14	10.2	137.4	75.1	230.5
Leukemia & Aleukemia	52	44.2	117.6	87.8	154.2
Cancer of All Other Lymphopoietic Tissue	38	28.2	134.6	95.2	184.7
Benign Neoplasms/Neoplasms of Unspecified Nature	17	9.8	172.7 *	100.6	276.6
Diabetes Mellitus	70	69.7	100.4	78.3	126.9
Cerebrovascular Disease	349	400.3	87.2 **	78.3	96.8
All Heart Disease	2026	2128.7	95.2 *	91.1	99.4
Rheumatic Heart Disease	24	27.6	87.0	55.8	129.5
Ischemic Heart Disease	1649	1816.8	90.8 **	86.4	95.3
Chronic Endocard. Dis.; Other Myocard. Insuff.	23	58.6	39.3 **	24.9	58.9
Hypertension with Heart Disease	42	32.4	129.6	93.4	175.1
Hypertension w/o Heart Disease	24	14.4	167.3 *	107.2	248.9
Non–malignant Respiratory Disease	264	364.5	72.4 **	64.0	81.7
Influenza & Pneumonia	91	142.9	63.7 **	51.3	78.2
Bronchitis, Emphysema, Asthma	92	115.8	79.5 *	64.1	97.5
Bronchitis	19	20.5	92.8	55.8	144.9
Emphysema	68	89.7	75.8 *	58.9	96.1
Asthma	5	6.4	77.6	25.2	181.2
Ulcer of Stomach & Duodenum	21	28.7	73.1	45.3	111.8
Cirrhosis of Liver	65	96.2	67.6 **	52.2	86.1
Nephritis & Nephrosis	29	29.5	98.4	65.9	141.3
All External Causes of Death	433	534.1	81.1 **	73.6	89.1
Accidents	295	347.7	84.9 **	75.4	95.1
Motor Vehicle Accidents	137	180.4	76.0 **	63.8	89.8
All Other Accidents	158	168.1	94.0	79.9	109.8
Suicides	96	105.1	91.3	74.0	111.5
Homicides & Other External Causes	42	55.4	75.9	54.7	102.6
All Other Causes of Death	520	580.5	89.6 *	82.0	97.6
Unknown Causes (In All Causes Category Only)	244				

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 8
Cause Specific SMRs for NON-WHITE MALES
Port Arthur Refinery Update, 1937-1987
Expected Deaths Based on TEXAS DEATH RATES

No. of Persons at Risk = 3,247 Person-Years = 88,404.7

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Observed	Expected	SMR	95% Confidence Interval	
				Lower	Upper
All Causes of Death	1342	1710.8	78.4 **	74.3	82.8
Tuberculosis	11	11.6	94.7	47.3	169.4
All Malignant Neoplasms	295	323.8	91.1	81.0	102.1
Cancer of Buccal Cavity & Pharynx	7	8.8	79.6	32.0	164.1
Cancer of Digestive Organs & Peritoneum	86	97.6	88.1	70.5	108.8
Cancer of Esophagus	11	13.9	79.4	39.7	142.1
Cancer of Stomach	35	27.1	129.3	90.0	179.8
Cancer of Large Intestine	18	21.0	85.8	50.8	135.6
Cancer of Rectum	1	6.0	16.7 *	0.4	93.2
Cancer of Biliary Passages & Liver	3	8.3	36.2	7.5	105.8
Cancer of Pancreas	17	17.8	95.7	55.7	153.2
Cancer of Respiratory System	80	100.5	79.6 *	63.1	99.1
Cancer of Bronchus, Trachea, Lung	75	94.5	79.4 *	62.5	99.5
Cancer of Breast	1	0.6	179.2	4.5	998.5
All Uterine Cancers (Females only)	0	0.0	---	---	---
Cancer of Cervix Uteri (Females only)	0	0.0	---	---	---
Cancer of Other Female Genital Organs	0	0.0	---	---	---
Cancer of Prostate (Males only)	36	44.2	81.4	57.0	112.8
Cancer of Testes and Other Male Genital Organs	1	1.6	63.1	1.6	351.8
Cancer of Kidney	10	5.0	202.1	96.9	371.7
Cancer of Bladder and Other Urinary Organs	7	7.8	90.3	36.3	186.1
Malignant Melanoma of Skin	0	0.6	---	0.0	578.6
Cancer of Eye	0	0.1	---	0.0	4759.6
Cancer of Central Nervous System	4	2.9	140.1	38.2	358.7
Cancer of Thyroid & Other Endocrine Glands	0	0.6	---	0.0	614.1
Cancer of Bone	2	1.4	146.0	17.7	527.3
Cancer of All Lymphatic, Haematopoietic Tissue	20	24.1	83.1	50.8	128.4
Lymphosarcoma & Reticulosarcoma	3	3.4	88.4	18.2	258.4
Hodgkins Disease	4	2.0	200.5	54.6	513.4
Leukemia & Aleukemia	4	9.0	44.3	12.1	113.4
Cancer of All Other Lymphopoietic Tissue	9	9.6	93.4	42.7	177.4
Benign Neoplasms/Neoplasms of Unspecified Nature	7	3.5	201.6	81.0	415.4
Diabetes Mellitus	31	24.6	125.8	85.5	178.6
Cerebrovascular Disease	137	176.8	77.5 **	65.0	91.6
All Heart Disease	441	582.3	75.7 **	68.8	83.1
Rheumatic Heart Disease	7	6.5	108.3	43.5	223.1
Ischemic Heart Disease	297	412.1	72.1 **	64.1	80.8
Chronic Endocard. Dis.; Other Myocard. Insuff.	20	19.4	103.3	63.1	159.5
Hypertension with Heart Disease	29	28.8	100.6	67.4	144.5
Hypertension w/o Heart Disease	8	14.6	54.7	23.6	107.7
Non-malignant Respiratory Disease	71	91.0	78.1 *	61.0	98.5
Influenza & Pneumonia	35	50.8	69.0 *	48.0	95.9
Bronchitis, Emphysema, Asthma	9	19.0	47.3 *	21.6	89.9
Bronchitis	2	3.5	57.9	7.0	209.2
Emphysema	4	11.1	36.2 *	9.9	92.7
Asthma	3	3.7	81.5	16.8	238.3
Ulcer of Stomach & Duodenum	7	7.5	94.0	37.8	193.6
Cirrhosis of Liver	11	20.0	55.0 *	27.4	98.4
Nephritis & Nephrosis	21	20.2	104.2	64.5	159.3
All External Causes of Death	93	204.0	45.6 **	36.8	55.9
Accidents	59	107.0	55.1 **	42.0	71.1
Motor Vehicle Accidents	23	51.6	44.6 **	28.3	66.9
All Other Accidents	36	55.5	64.9 **	45.5	89.8
Suicides	9	8.6	105.0	48.0	199.2
Homicides & Other External Causes	25	79.8	31.3 **	20.3	46.2
All Other Causes of Death	132	215.8	61.2 **	51.2	72.6
Unknown Causes (In All Causes Category Only)	77				

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 9
Cause Specific SMRs for WHITE FEMALES
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

No. of Persons at Risk = 1,778 Person–Years = 47,910.7

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Observed	Expected	SMR	95% Confidence Interval	
				Lower	Upper
All Causes of Death	267	239.8	111.3	98.4	125.5
Tuberculosis	0	1.0	---	0.0	368.6
All Malignant Neoplasms	89	70.3	126.5 *	101.6	155.7
Cancer of Buccal Cavity & Pharynx	2	1.0	198.5	24.0	717.1
Cancer of Digestive Organs & Peritoneum	20	14.6	137.4	83.9	212.2
Cancer of Esophagus	1	0.6	175.8	4.4	979.8
Cancer of Stomach	2	2.1	97.3	11.8	351.3
Cancer of Large Intestine	9	5.9	152.2	69.6	288.8
Cancer of Rectum	3	1.0	291.3	60.1	851.4
Cancer of Biliary Passages & Liver	0	1.5	---	0.0	244.5
Cancer of Pancreas	4	3.1	129.1	35.2	330.6
Cancer of Respiratory System	15	11.3	132.6	74.2	218.7
Cancer of Bronchus, Trachea, Lung	15	10.9	137.1	76.7	226.2
Cancer of Breast	20	15.0	133.7	81.7	206.5
All Uterine Cancers (Females only)	7	6.0	117.4	47.2	241.8
Cancer of Cervix Uteri (Females only)	3	3.7	80.4	16.6	234.9
Cancer of Other Female Genital Organs	5	5.1	98.7	32.0	230.3
Cancer of Prostate (Males only)	0	0.0	---	---	---
Cancer of Testes and Other Male Genital Organs	0	0.0	---	---	---
Cancer of Kidney	3	1.1	277.5	57.3	810.9
Cancer of Bladder and Other Urinary Organs	1	0.6	165.9	4.1	924.5
Malignant Melanoma of Skin	0	1.2	---	0.0	320.9
Cancer of Eye	0	0.1	---	0.0	6659.8
Cancer of Central Nervous System	3	2.1	140.2	28.9	409.6
Cancer of Thyroid & Other Endocrine Glands	1	0.3	294.4	7.4	1640.4
Cancer of Bone	1	0.3	386.1	9.7	2151.5
Cancer of All Lymphatic, Haematopoietic Tissue	5	6.2	80.7	26.2	188.3
Lymphosarcoma & Reticulosarcoma	1	1.1	87.4	2.2	487.3
Hodgkins Disease	0	0.5	---	0.0	691.0
Leukemia & Aleukemia	1	2.5	40.7	1.0	226.7
Cancer of All Other Lymphopoietic Tissue	3	2.1	145.6	30.0	425.4
Benign Neoplasms/Neoplasms of Unspecified Nature	4	1.0	420.5 *	114.6	1076.8
Diabetes Mellitus	6	6.0	100.4	36.8	218.5
Cerebrovascular Disease	16	20.6	77.5	44.3	125.9
All Heart Disease	64	66.5	96.3	74.1	122.9
Rheumatic Heart Disease	1	2.5	39.9	1.0	222.4
Ischemic Heart Disease	45	49.7	90.6	66.1	121.3
Chronic Endocard. Dis.; Other Myocard. Insuff.	1	3.3	30.4	0.8	169.2
Hypertension with Heart Disease	1	1.9	51.8	1.3	288.6
Hypertension w/o Heart Disease	0	0.7	---	0.0	561.2
Non–malignant Respiratory Disease	10	13.1	76.1	36.5	140.0
Influenza & Pneumonia	5	5.6	89.7	29.1	209.3
Bronchitis, Emphysema, Asthma	0	2.9	---	0.0	128.5
Bronchitis	0	0.6	---	0.0	669.3
Emphysema	0	1.7	---	0.0	211.5
Asthma	0	0.5	---	0.0	743.4
Ulcer of Stomach & Duodenum	0	0.8	---	0.0	458.8
Cirrhosis of Liver	3	5.3	56.3	11.6	164.4
Nephritis & Nephrosis	0	1.7	---	0.0	217.6
All External Causes of Death	20	19.4	103.1	63.0	159.3
Accidents	12	12.3	97.6	50.4	170.4
Motor Vehicle Accidents	9	7.3	123.8	56.6	235.0
All Other Accidents	3	5.1	58.8	12.1	171.8
Suicides	6	4.5	134.8	49.5	293.5
Homicides & Other External Causes	2	1.8	108.8	13.2	393.1
All Other Causes of Death	29	33.2	87.4	58.5	125.5
Unknown Causes (In All Causes Category Only)	26				

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 10
Cause Specific SMRs for ALL COHORT MEMBERS Stratified by Length of Employment
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 1 year		1–9 years		10–19 years		20–29 years		30+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	1346	109.8 **	1135	95.8	784	87.2 **	1167	87.0 **	2367	88.2 **
Tuberculosis	5	82.9	9	136.7	7	111.2	6	73.2	6	51.6
All Malignant Neoplasms	305	114.7 *	242	102.4	144	88.3	270	112.6	521	96.6
Cancer of Buccal Cavity & Pharynx	11	148.9	4	61.7	4	82.0	7	92.2	10	68.5
Cancer of Digestive Organs & Peritoneum	67	108.5	56	98.9	32	74.1	81	119.8	141	98.9
Cancer of Esophagus	8	136.4	2	35.0	3	78.2	3	50.2	7	55.3
Cancer of Stomach	13	116.3	11	98.8	8	77.9	27	156.7 *	36	118.6
Cancer of Large Intestine	19	99.7	18	107.8	10	87.8	23	134.1	47	111.6
Cancer of Rectum	2	46.7	3	76.7	5	159.9	5	100.6	11	109.8
Cancer of Biliary Passages & Liver	3	52.2	2	38.5	0	---	4	86.0	4	33.0 *
Cancer of Pancreas	20	142.2	18	146.8	5	55.0	19	135.8	32	102.0
Cancer of Respiratory System	104	109.0	77	94.8	52	99.0	59	78.5	156	86.1
Cancer of Bronchus, Trachea, Lung	101	111.0	72	93.3	49	98.9	57	80.9	144	83.9 *
Cancer of Breast	6	83.3	11	197.7	1	61.9	1	65.6	3	182.8
All Uterine Cancers (Females only)	2	74.0	1	43.1	0	---	2	360.7	2	437.8
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---	1	316.2	2	888.6 *
Cancer of Other Female Genital Organs	2	86.9	2	115.8	0	---	0	---	1	249.5
Cancer of Prostate (Males only)	14	88.3	12	80.0	10	76.6	25	109.8	65	101.1
Cancer of Testes and Other Male Genital Organs	1	75.9	1	57.7	2	182.7	0	---	1	79.3
Cancer of Kidney	9	147.9	6	115.1	4	110.2	7	134.2	14	125.9
Cancer of Bladder and Other Urinary Organs	3	59.6	5	111.3	2	52.3	4	64.4	11	72.3
Malignant Melanoma of Skin	5	117.6	4	103.1	4	154.7	2	67.2	6	119.5
Cancer of Eye	0	---	0	---	0	---	1	413.8	1	264.6
Cancer of Central Nervous System	12	154.3	6	86.1	4	87.1	6	113.3	11	129.4
Cancer of Thyroid & Other Endocrine Glands	1	109.4	2	242.2	1	166.8	0	---	3	204.7
Cancer of Bone	2	181.6	3	271.1	2	244.8	3	242.9	3	150.3
Cancer of All Lymphatic, Haematopoietic Tissue	25	100.5	23	99.0	10	61.1	33	152.6 *	47	103.0
Lymphosarcoma & Reticulosarcoma	3	68.6	3	75.4	2	64.7	3	72.1	2	26.9 *
Hodgkins Disease	3	110.7	5	170.5	1	47.3	4	185.1	5	176.8
Leukemia & Aleukemia	8	79.0	5	52.4	5	73.6	21	222.7 **	18	90.2
Cancer of All Other Lymphopoietic Tissue	11	143.4	10	147.3	2	45.9	5	85.5	22	142.7

(continued)

Table 10 continued
Cause Specific SMRs for ALL COHORT MEMBERS Stratified by Length of Employment

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 1 year		1–9 years		10–19 years		20–29 years		30+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
Benign Neoplasms/Neoplasms of Unspecified Nature	3	108.8	4	148.3	4	216.6	5	207.2	12	257.9 **
Diabetes Mellitus	12	69.6	17	104.2	11	90.7	19	107.4	48	127.0
Cerebrovascular Disease	61	80.9	55	75.1 *	49	73.3 *	113	90.6	224	86.1 *
All Heart Disease	439	100.8	357	91.5	281	86.0 *	449	83.6 **	1008	92.0 **
Rheumatic Heart Disease	3	40.4	3	41.0	5	84.9	8	119.3	13	138.4
Ischemic Heart Disease	359	101.7	293	94.6	213	78.8 **	347	76.6 **	782	87.1 **
Chronic Endocard. Dis.; Other Myocard. Insuff.	3	22.3 **	1	8.2 **	9	110.3	16	134.8	15	41.8 **
Hypertension with Heart Disease	7	76.9	6	61.5	5	65.9	26	214.3 **	28	111.3
Hypertension w/o Heart Disease	1	25.8	2	42.9	5	106.5	4	61.4	20	197.9 **
Non–malignant Respiratory Disease	82	113.7	55	85.0	48	91.5	47	56.1 **	114	58.1 **
Influenza & Pneumonia	25	92.7	23	87.8	22	94.6	20	50.1 **	42	50.4 **
Bronchitis, Emphysema, Asthma	26	127.6	15	86.1	10	63.1	16	60.6 *	34	58.8 **
Bronchitis	3	87.9	0	---	1	35.8	6	121.2	11	105.1
Emphysema	22	145.0	14	112.9	7	62.0	9	46.6 *	20	45.1 **
Asthma	1	58.6	1	52.4	2	125.2	1	46.5	3	90.1
Ulcer of Stomach & Duodenum	5	89.7	5	92.5	5	94.2	2	25.1 *	11	86.1
Cirrhosis of Liver	23	86.1	14	57.7 *	3	17.1 **	12	52.4 *	27	88.6
Nephritis & Nephrosis	6	76.4	8	91.8	7	97.8	9	91.6	20	110.7
All External Causes of Death	138	81.8 *	153	70.1 **	77	59.1 **	76	66.6 **	103	80.6 *
Accidents	80	77.2 *	104	81.2 *	51	66.0 **	61	84.7	71	81.6
Motor Vehicle Accidents	39	69.2 *	50	70.0 **	19	47.6 **	30	87.8	31	82.1
All Other Accidents	41	86.3	54	94.7	32	85.5	31	82.0	40	81.0
Suicides	32	117.3	24	80.0	14	73.1	12	63.7	29	126.4
Homicides & Other External Causes	26	86.2	25	49.8 **	12	45.3 **	3	17.2 **	3	22.3 **
All Other Causes of Death	115	85.4	108	83.1	82	83.7	133	88.0	246	77.0 **
Unknown Causes (In All Causes Category Only)	151		106		61		22		7	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL
# SIGNIFICANT DEFICIT AT 5% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED.

Table 11
Cause Specific SMRs for WHITE MALES Stratified by Length of Employment
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 1 year		1–9 years		10–19 years		20–29 years		30+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	1073	115.2 **	802	102.6	582	92.0 *	911	91.3 **	1812	89.8 **
Tuberculosis	4	95.3	5	131.2	5	127.4	3	52.5	5	59.7
All Malignant Neoplasms	225	114.8 *	163	105.5	106	91.1	203	114.7	399	99.3
Cancer of Buccal Cavity & Pharynx	10	173.2	2	44.7	3	84.2	6	104.1	6	52.1
Cancer of Digestive Organs & Peritoneum	45	100.7	35	99.7	23	79.4	55	115.1	113	110.9
Cancer of Esophagus	3	80.1	1	35.0	1	48.4	1	29.9	5	66.3
Cancer of Stomach	6	77.4	5	79.3	5	81.6	14	123.8	28	145.0
Cancer of Large Intestine	14	99.0	13	117.8	7	82.9	17	129.0	39	120.8
Cancer of Rectum	1	30.9	2	77.8	5	229.0	5	134.8	9	119.7
Cancer of Biliary Passages & Liver	3	74.9	1	32.4	0	---	3	94.2	3	34.6
Cancer of Pancreas	17	159.1	11	134.4	4	60.7	15	142.6	26	109.8
Cancer of Respiratory System	84	110.1	58	100.3	42	104.6	42	72.7 *	126	89.3
Cancer of Bronchus, Trachea, Lung	82	112.7	53	96.2	40	105.4	41	75.5	117	87.5
Cancer of Breast	0	---	0	---	0	---	0	---	0	---
All Uterine Cancers (Females only)	0	---	0	---	0	---	0	---	0	---
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---	0	---	0	---
Cancer of Other Female Genital Organs	0	---	0	---	0	---	0	---	0	---
Cancer of Prostate (Males only)	13	107.7	10	109.4	5	60.7	20	129.2	42	100.3
Cancer of Testes and Other Male Genital Organs	1	88.5	1	71.9	1	126.4	0	---	1	123.5
Cancer of Kidney	4	80.4	2	51.6	3	105.5	7	165.4	11	119.0
Cancer of Bladder and Other Urinary Organs	3	74.8	4	129.4	2	72.1	2	42.1	6	51.1
Malignant Melanoma of Skin	5	135.9	4	118.7	4	168.2	2	72.1	6	127.2
Cancer of Eye	0	---	0	---	0	---	1	471.6	1	287.1
Cancer of Central Nervous System	12	189.2	3	54.0	2	50.2	6	128.6	9	119.5
Cancer of Thyroid & Other Endocrine Glands	1	145.6	1	170.9	1	202.8	0	---	3	245.4
Cancer of Bone	1	121.2	3	402.8	2	335.7	3	313.5	1	67.5
Cancer of All Lymphatic, Haematopoietic Tissue	17	88.4	18	109.7	6	48.1	31	182.1 **	41	114.0
Lymphosarcoma & Reticulosarcoma	1	28.8	1	34.4	2	81.5	3	87.6	2	32.3
Hodgkins Disease	3	138.5	5	228.7	0	---	4	223.5	2	83.9
Leukemia & Aleukemia	7	87.8	5	72.3	4	74.5	19	246.3 **	17	104.6
Cancer of All Other Lymphopoietic Tissue	6	106.6	7	158.9	0	---	5	122.6	20	179.7 *

(continued)

Table 11 continued
Cause Specific SMRs for WHITE MALES Stratified by Length of Employment

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 1 year		1–9 years		10–19 years		20–29 years		30+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
Benign Neoplasms/Neoplasms of Unspecified Nature	0	---	2	121.3	4	328.6	3	182.4	8	233.4 *
Diabetes Mellitus	10	83.7	14	143.1	5	61.4	13	103.1	28	102.9
Cerebrovascular Disease	45	86.4	33	80.5	28	67.6 *	88	102.2	155	86.3
All Heart Disease	369	105.5	278	101.2	227	93.4	364	87.7 *	788	93.1 *
Rheumatic Heart Disease	2	36.9	3	61.1	2	45.2	6	114.4	11	145.2
Ischemic Heart Disease	310	105.6	236	102.5	174	82.7 *	288	79.2 **	641	89.1 **
Chronic Endocard. Dis.; Other Myocard. Insuff.	1	9.9 **	0	---##	5	86.4	12	143.3	5	18.9 **
Hypertension with Heart Disease	5	97.0	4	99.5	3	90.8	16	248.9 **	14	103.6
Hypertension w/o Heart Disease	1	50.8	2	123.4	5	289.9	2	61.1	14	243.0 **
Non–malignant Respiratory Disease	67	117.6	35	78.4	35	90.6	34	52.0 **	93	58.6 **
Influenza & Pneumonia	19	95.6	13	81.1	15	97.8	12	41.4 **	32	51.1 **
Bronchitis, Emphysema, Asthma	24	140.5	13	98.9	8	63.0	13	58.0 *	34	67.4 *
Bronchitis	3	104.5	0	---	1	44.7	4	96.4	11	122.0
Emphysema	20	150.3	12	118.3	7	72.3	9	53.0	20	50.5 **
Asthma	1	100.9	1	119.1	0	---	0	---	3	128.7
Ulcer of Stomach & Duodenum	4	91.0	3	81.5	4	105.6	1	15.8 *	9	85.6
Cirrhosis of Liver	19	89.9	10	58.1	2	15.0 **	12	64.2	22	85.3
Nephritis & Nephrosis	6	122.1	4	91.3	4	104.9	7	124.2	8	74.6
All External Causes of Death	111	88.3	117	82.0 *	60	68.7 **	61	74.0 *	84	87.6
Accidents	68	83.5	82	89.3	40	72.0 *	48	89.3	57	87.5
Motor Vehicle Accidents	34	76.3	40	76.7	13	44.8 **	25	97.1	25	86.7
All Other Accidents	34	91.5	42	105.2	27	101.4	23	82.2	32	87.9
Suicides	27	113.4	20	78.9	12	69.8	11	63.0	26	122.0
Homicides & Other External Causes	16	110.1	15	80.7	8	85.0	2	29.3	1	16.7 *
All Other Causes of Death	91	93.1	65	80.6	65	99.1	105	98.0	194	84.5 *
Unknown Causes (In All Causes Category Only)	121		71		32		15		5	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL
SIGNIFICANT DEFICIT AT 1% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED.

Table 12
Cause Specific SMRs for NON–WHITE MALES Stratified by Length of Employment
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 1 year		1–9 years		10–19 years		20–29 years		30+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	170	87.8	240	75.2 **	178	72.4 **	227	71.9	527	82.8 **
Tuberculosis	1	72.8	4	168.3	2	88.6	3	124.5	1	31.3
All Malignant Neoplasms	43	112.7	47	82.0	33	81.8	58	103.0	114	86.6
Cancer of Buccal Cavity & Pharynx	1	86.9	1	59.7	1	81.2	0	--- ##	4	133.4
Cancer of Digestive Organs & Peritoneum	13	119.7	16	95.9	7	54.2	23	126.7	27	69.2
Cancer of Esophagus	4	216.6	1	37.8	2	116.3	2	77.6 **	2	39.6
Cancer of Stomach	5	195.1	6	146.0	3	76.4	13	229.2	8	74.0
Cancer of Large Intestine	2	82.3	2	53.8	2	82.5	4	121.1	8	87.8
Cancer of Rectum	0	---	0	---	0	---	0	--- #	1	41.9
Cancer of Biliary Passages & Liver	0	---	1	61.8	0	---	1	76.6	1	30.5
Cancer of Pancreas	2	98.1	6	196.5	0	---	3	96.1	6	81.9
Cancer of Respiratory System	12	87.7	12	61.5	9	77.8	17	103.0	30	76.5
Cancer of Bronchus, Trachea, Lung	12	92.9	12	65.3	8	74.2	16	104.2	27	72.9
Cancer of Breast	0	---	1	1018.8	0	---	0	---	0	---
All Uterine Cancers (Females only)	0	---	0	---	0	---	0	---	0	---
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---	0	--- #	0	---
Cancer of Other Female Genital Organs	0	---	0	---	0	---	0	---	0	---
Cancer of Prostate (Males only)	1	26.4	2	34.2	5	103.6	5	68.6 **	23	102.5
Cancer of Testes and Other Male Genital Organs	0	---	0	---	1	329.0	0	---	0	---
Cancer of Kidney	4	635.8 **	3	308.5	1	143.7	0	---	2	113.1
Cancer of Bladder and Other Urinary Organs	0	---	0	---	0	---	2	145.1	5	147.5
Malignant Melanoma of Skin	0	---	0	---	0	---	0	---	0	---
Cancer of Eye	0	---	0	---	0	---	0	--- ##	0	---
Cancer of Central Nervous System	0	---	1	149.9	1	239.3	0	--- #	2	236.0
Cancer of Thyroid & Other Endocrine Glands	0	---	0	---	0	---	0	---	0	---
Cancer of Bone	0	---	0	---	0	---	0	---	2	406.0
Cancer of All Lymphatic, Haematopoietic Tissue	3	102.7	5	107.1	4	119.7	2	49.8	6	65.9
Lymphosarcoma & Reticulosarcoma	1	245.5	2	289.3	0	---	0	---	0	---
Hodgkins Disease	0	---	0	---	1	251.1	0	---	3	723.0 *
Leukemia & Aleukemia	0	---	0	---	1	82.7	2	134.9	1	28.7
Cancer of All Other Lymphopoietic Tissue	2	180.2	3	177.9	2	166.1	0	---	2	49.2

(continued)

Table 12 continued
Cause Specific SMRs for NON–WHITE MALES Stratified by Length of Employment

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 1 year		1–9 years		10–19 years		20–29 years		30+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
Benign Neoplasms/Neoplasms of Unspecified Nature	1	237.8	0	---	0	---	2	293.3	4	349.4
Diabetes Mellitus	2	73.7	1	22.9	5	145.9	6	137.8	17	173.9 *
Cerebrovascular Disease	11	69.2	16	66.8	17	72.0	24	68	68	88.8
All Heart Disease	46	76.6	61	71.4 **	49	62.8 **	71	63.3	208	87.3 *
Rheumatic Heart Disease	1	115.6	0	---	3	246.9	1	79.9	2	120.9
Ischemic Heart Disease	32	78.4	45	76.7	34	61.1 **	49	59.6	133	78.4 **
Chronic Endocard. Dis.; Other Myocard. Insuff.	1	47.1	1	31.1	4	185.6	4	133.9	10	112.5
Hypertension with Heart Disease	2	64.3	2	40.4	2	48.9	9	166.4	14	124.3
Hypertension w/o Heart Disease	0	---	0	---	0	---	2	63.8	6	142
Non–malignant Respiratory Disease	11	112.7	16	101.5	12	93.8	12	71.2	20	55.9 **
Influenza & Pneumonia	5	99.0	8	96.0	6	80.5	7	69.6	9	45.3 *
Bronchitis, Emphysema, Asthma	2	99.3	2	60.3	2	69.2	3	81.1	0	--- ##
Bronchitis	0	---	0	---	0	---	2	269.6	0	---
Emphysema	2	180.8	2	116.4	0	---	0	---	0	--- #
Asthma	0	---	0	---	2	280.8	1	149.8	0	---
Ulcer of Stomach & Duodenum	1	117.4	2	137.8	1	69.4	1	65	2	92.4
Cirrhosis of Liver	2	66.4	3	58.8	1	27.1	0	---	5	113.9
Nephritis & Nephrosis	0	---	4	109.4	3	94.1	2	50	12	168.4
All External Causes of Death	21	62.0 *	23	40.1 **	13	31.5 **	13	42.6	19	61.1 *
Accidents	9	54.4	13	54.4 **	8	38.9 **	11	63.1	14	66.1
Motor Vehicle Accidents	3	35.6	5	43.2 *	3	29.3 *	4	49.8	6	69.2
All Other Accidents	6	73.8	8	66.3	5	48.3	7	74.6	8	64
Suicides	3	216.3	1	34.5	1	63.4	1	84	3	196.7
Homicides & Other External Causes	9	61.5	9	29.6 **	4	23.7 **	1	9.5	2	26.9 *
All Other Causes of Death	11	48.1 **	28	75.0	16	54.2 **	27	67	50	58.3 **
Unknown Causes (In All Causes Category Only)	20		22		26		6		1	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL
# SIGNIFICANT DEFICIT AT 5% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED.
SIGNIFICANT DEFICIT AT 1% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED.

Table 13
Cause Specific SMRs for WHITE FEMALES Stratified by Length of Employment
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 1 year		1–9 years		10–19 years		20–29 years		30+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	101	105.4	87	119.2	24	123.1	29	108.4	26	105.1
Tuberculosis	0	---	0	---	0	---	0	---	0	---
All Malignant Neoplasms	36	117.3	31	139.8	5	84.4	9	146.0	8	148.3
Cancer of Buccal Cavity & Pharynx	0	---	1	320.9	0	---	1	1145.0	0	---
Cancer of Digestive Organs & Peritoneum	9	152.2	5	115.2	2	161.3	3	186.8	1	68.7
Cancer of Esophagus	1	407.7	0	---	0	---	0	---	0	---
Cancer of Stomach	2	244.9	0	---	0	---	0	---	0	---
Cancer of Large Intestine	3	124.9	3	170.5	1	205.0	2	304.6	0	---
Cancer of Rectum	1	242.1	1	324.8	0	---	0	---	1	997.5
Cancer of Biliary Passages & Liver	0	---	0	---	0	---	0	---	0	---
Cancer of Pancreas	1	78.3	1	109.4	1	402.1	1	295.6	0	---
Cancer of Respiratory System	7	131.7	7	195.7	1	126.5	0	---	0	---
Cancer of Bronchus, Trachea, Lung	7	136.0	7	202.3	1	131.5	0	---	0	---
Cancer of Breast	6	89.2	9	185.6	1	76.4	1	86.3	3	328.4
All Uterine Cancers (Females only)	2	79.1	1	51.1	0	---	2	395.7	2	562.2
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---	1	349.2	2	1142.2
Cancer of Other Female Genital Organs	2	89.6	2	125.2	0	---	0	---	1	277.5
Cancer of Prostate (Males only)	0	---	0	---	0	---	0	---	0	---
Cancer of Testes and Other Male Genital Organs	0	---	0	---	0	---	0	---	0	---
Cancer of Kidney	1	214.9	1	302.2	0	---	0	---	1	1041.9
Cancer of Bladder and Other Urinary Organs	0	---	1	587.5	0	---	0	---	0	---
Malignant Melanoma of Skin	0	---	0	---	0	---	0	---	0	---
Cancer of Eye	0	---	0	---	0	---	0	---	0	---
Cancer of Central Nervous System	0	---	2	279.7	1	547.3	0	---	0	---
Cancer of Thyroid & Other Endocrine Glands	0	---	1	926.9	0	---	0	---	0	---
Cancer of Bone	1	925.9	0	---	0	---	0	---	0	---
Cancer of All Lymphatic, Haematopoietic Tissue	5	189.8	0	---	0	---	0	---	0	---
Lymphosarcoma & Reticulosarcoma	1	206.7	0	---	0	---	0	---	0	---
Hodgkins Disease	0	---	0	---	0	---	0	---	0	---
Leukemia & Aleukemia	1	97.3	0	---	0	---	0	---	0	---
Cancer of All Other Lymphopoietic Tissue	3	335.8	0	---	0	---	0	---	0	---

(continued)

Table 13 continued
Cause Specific SMRs for WHITE FEMALES Stratified by Length of Employment

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 1 year		1–9 years		10–19 years		20–29 years		30+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
Benign Neoplasms/Neoplasms of Unspecified Nature	2	490.1	2	642.9	0	---	0	---	0	---
Diabetes Mellitus	0	---	2	112.6	1	201.8	0	---	3	472.1
Cerebrovascular Disease	5	72.2	5	87.7	4	234.6	1	31.1	1	32.4
All Heart Disease	24	99.1	10	53.9 *	5	96.3	14	149.2	11	120.4
Rheumatic Heart Disease	0	---	0	---	0	---	1	504.4	0	---
Ischemic Heart Disease	17	96.6	6	44.0 *	5	126.7	10	136.7	7	97.7
Chronic Endocard. Dis.; Other Myocard. Insuff.	1	82.0	0	---	0	---	0	---	0	---
Hypertension with Heart Disease	0	---	0	---	0	---	1	375.6	0	---
Hypertension w/o Heart Disease	0	---	0	---	0	---	0	---	0	---
Non–malignant Respiratory Disease	4	76.5	4	102.3	1	101.8	1	65.7	0	---
Influenza & Pneumonia	1	51.0	2	124.5	1	231.4	1	124.1	0	---
Bronchitis, Emphysema, Asthma	0	---	0	---	0	---	0	---	0	---
Bronchitis	0	---	0	---	0	---	0	---	0	---
Emphysema	0	---	0	---	0	---	0	---	0	---
Asthma	0	---	0	---	0	---	0	---	0	---
Ulcer of Stomach & Duodenum	0	---	0	---	0	---	0	---	0	---
Cirrhosis of Liver	2	80.9	1	56.7	0	---	0	---	0	---
Nephritis & Nephrosis	0	---	0	---	0	---	0	---	0	---
All External Causes of Death	6	70.0	8	110.8	4	238.7	2	174.2	0	---
Accidents	3	56.1	4	89.5	3	288.0	2	240.4	0	---
Motor Vehicle Accidents	2	61.1	3	108.3	3	490.0 *	1	261.2	0	---
All Other Accidents	1	47.4	1	57.8	0	---	1	221.1	0	---
Suicides	2	98.2	3	176.4	1	251.6	0	---	0	---
Homicides & Other External Causes	1	121.9	1	135.0	0	---	0	---	0	---
All Other Causes of Death	12	90.8	13	126.1	1	38.1	1	27.4	2	58.9
Unknown Causes (In All Causes Category Only)	10		11		3		1		1	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 14
Cause Specific SMRs for ALL COHORT MEMBERS Stratified by Years Since Hired
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 10 years		10–19 years		20–29 years		30–39 years		40+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	269	76.2 **	567	83.2 **	1128	81.9 **	1949	96.8	2886	99.1
Tuberculosis	7	226.0	7	97.9	7	71.4	8	82.2	4	44.7
All Malignant Neoplasms	26	71.7	87	84.5	247	92.6	483	107.2	639	108.7 *
Cancer of Buccal Cavity & Pharynx	1	108.3	4	112.4	9	97.8	10	73.7	12	87.7
Cancer of Digestive Organs & Peritoneum	5	58.6	18	65.3	71	100.1	122	105.7	161	107.8
Cancer of Esophagus	0	---	0	---	5	70.8	8	66.7	10	82.2
Cancer of Stomach	0	---	7	90.2	20	113.8	37	152.4 *	31	110.2
Cancer of Large Intestine	1	46.1	7	115.4	15	90.3	34	106.3	60	121.0
Cancer of Rectum	1	135.8	1	46.4	5	96.8	3	37.8	16	154.9
Cancer of Biliary Passages & Liver	0	---	0	---	6	120.3	3	30.4 *	4	28.4 **
Cancer of Pancreas	3	236.1	3	56.1	19	122.9	32	124.5	37	112.1
Cancer of Respiratory System	6	93.4	22	76.5	65	70.2 **	156	94.2	199	103.7
Cancer of Bronchus, Trachea, Lung	6	102.9	20	74.9	61	70.0 **	148	94.1	188	102.8
Cancer of Breast	1	115.0	1	44.5	5	104.9	9	149.3	6	165.0
All Uterine Cancers (Females only)	0	---	1	69.5	0	---	3	173.5	3	312.6
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---	1	109.1	2	502.1
Cancer of Other Female Genital Organs	0	---	0	---	1	70.1	2	102.7	2	180.0
Cancer of Prostate (Males only)	2	352.5	1	31.9	11	86.0	25	75.3	87	107.0
Cancer of Testes and Other Male Genital Organs	0	---	2	138.2	2	166.9	1	91.7	0	---
Cancer of Kidney	1	128.1	4	160.8	7	108.6	14	137.3	14	123.2
Cancer of Bladder and Other Urinary Organs	1	232.1	1	55.4	2	37.7	5	50.3	16	92.4
Malignant Melanoma of Skin	1	64.1	2	72.2	4	92.6	6	120.6	8	157.2
Cancer of Eye	0	---	0	---	1	410.0	0	---	1	280.6
Cancer of Central Nervous System	0	---	4	80.9	7	83.8	18	184.2 *	10	132.1
Cancer of Thyroid & Other Endocrine Glands	1	419.8	1	177.1	1	92.7	2	145.8	2	145.8
Cancer of Bone	1	164.9	2	260.2	1	69.4	8	454.1 **	1	59.6
Cancer of All Lymphatic, Haematopoietic Tissue	3	42.2	14	105.5	24	96.7	44	119.5	53	106.6
Lymphosarcoma & Reticulosarcoma	0	---	1	33.8	4	73.3	6	90.8	2	29.8
Hodgkins Disease	0	---	5	183.5	4	125.9	6	221.9	3	130.1
Leukemia & Aleukemia	3	91.4	6	109.5	8	79.8	19	127.1	21	94.9
Cancer of All Other Lymphopoietic Tissue	0	---	2	94.9	8	130.1	13	103.7	27	145.2

(continued)

Table 14 continued
Cause Specific SMRs for ALL COHORT MEMBERS Stratified by Years Since Hired

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 10 years		10–19 years		20–29 years		30–39 years		40+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
Benign Neoplasms/Neoplasms of Unspecified Nature	1	104.3	4	242.5	3	101.9	10	259.6 *	10	201.6
Diabetes Mellitus	1	27.6	5	58.5	12	66.2	37	127.5	52	124.2
Cerebrovascular Disease	6	54.1	28	75.8	64	67.2 **	126	80.4 *	278	92.6
All Heart Disease	33	53.7 **	164	76.4 **	397	75.1 **	765	95.0	1175	100.0
Rheumatic Heart Disease	0	---	1	14.6 *	9	95.4	10	109.2	12	153.0
Ischemic Heart Disease	25	52.0 **	141	77.7 **	332	73.3 **	606	91.3 *	890	95.0
Chronic Endocard. Dis.; Other Myocard. Insuff.	1	87.9	5	168.6	11	167.5	16	81.6	11	21.5 **
Hypertension with Heart Disease	0	---	3	59.3	12	111.8	30	159.5 *	27	98.0
Hypertension w/o Heart Disease	1	67.8	2	45.1	2	29.7	11	154.2	16	158.5
Non-malignant Respiratory Disease	7	66.2	19	66.9	43	61.5 **	95	76.4 **	182	77.1 **
Influenza & Pneumonia	4	67.1	9	60.6	21	68.1	33	69.6 *	65	64.6 **
Bronchitis, Emphysema, Asthma	1	37.9	6	64.2	13	49.9 **	34	84.5	47	78.9
Bronchitis	0	---	0	---	3	63.3	7	97.7	11	104.7
Emphysema	0	---	4	71.1	10	53.6 *	24	79.6	34	72.5
Asthma	1	121.8	2	119.2	0	---	3	99.9	2	74.0
Ulcer of Stomach & Duodenum	2	113.4	0	--- #	2	22.8 *	11	110.5	13	113.7
Cirrhosis of Liver	2	30.2	4	21.8 **	21	58.2 **	31	84.0	21	87.8
Nephritis & Nephrosis	3	84.3	6	95.6	9	91.5	11	90.8	21	105.9
All External Causes of Death	103	57.1 **	126	72.3 **	117	68.6 **	104	79.4 *	97	93.9
Accidents	67	63.7 **	92	91.4	77	74.2 **	73	87.1	58	77.9
Motor Vehicle Accidents	32	49.8 **	42	77.2	41	77.5	31	78.3	23	80.7
All Other Accidents	35	84.4	50	107.9	36	70.7 *	42	94.9	35	75.9
Suicides	11	54.0 *	14	56.1 *	31	106.1	20	80.0	35	187.1 **
Homicides & Other External Causes	25	56.1 **	20	53.0 **	9	30.6 **	11	61.6	4	48.8
All Other Causes of Death	21	62.4 *	45	66.4 **	98	69.4 **	177	80.0 **	343	92.9
Unknown Causes (In All Causes Category Only)	56		70		106		80		35	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL
# SIGNIFICANT DEFICIT AT 5% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED.

Table 15
Cause Specific SMRs for WHITE MALES Stratified by Years Since Hired
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 10 years		10–19 years		20–29 years		30–39 years		40+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	212	91.4	443	94.8	879	88.8 **	1464	99.9	2182	98.8
Tuberculosis	4	218.3	5	114.1	4	61.9	6	88.2	3	45.8
All Malignant Neoplasms	21	84.0	69	95.8	180	94.9	352	109.4	474	108.5
Cancer of Buccal Cavity & Pharynx	1	154.7	4	160.5	7	103.8	7	68.4	8	72.9
Cancer of Digestive Organs & Peritoneum	5	90.9	15	81.6	47	98.0	93	117.6	111	103.3
Cancer of Esophagus	0	---	0	---	2	54.2	5	74.4	4	51.9
Cancer of Stomach	0	---	5	103.3	9	82.4	24	156.3 *	20	110.0
Cancer of Large Intestine	1	70.6	7	157.6	9	72.8	29	123.9	44	117.5
Cancer of Rectum	1	212.4	1	67.2	4	107.4	3	51.9	13	167.5
Cancer of Biliary Passages & Liver	0	---	0	---	5	155.5	3	45.7	2	19.7 **
Cancer of Pancreas	3	318.9	2	50.2	17	149.3	24	128.1	27	109.8
Cancer of Respiratory System	5	105.5	19	86.5	53	74.9 *	115	91.7	160	106.5
Cancer of Bronchus, Trachea, Lung	5	115.5	18	87.8	50	74.8 *	108	90.7	152	106.2
Cancer of Breast	0	---	0	---	0	---	0	---	0	---
All Uterine Cancers (Females only)	0	---	0	---	0	---	0	---	0	---
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---	0	---	0	---
Cancer of Other Female Genital Organs	0	---	0	---	0	---	0	---	0	---
Cancer of Prostate (Males only)	2	556.6	1	50.2	6	72.6	19	87.4	62	113.9
Cancer of Testes and Other Male Genital Organs	0	---	1	87.8	2	234.1	1	145.1	0	---
Cancer of Kidney	0	---	2	105.7	5	97.3	11	134.3	9	95.6
Cancer of Bladder and Other Urinary Organs	0	---	1	80.8	2	52.1	3	40.5	11	80.9
Malignant Melanoma of Skin	1	70.6	2	80.1	4	103.4	6	134.4	8	171.2
Cancer of Eye	0	---	0	---	1	487.6	0	---	1	306.9
Cancer of Central Nervous System	0	---	2	47.6	6	84.6	15	184.4 *	9	137.7
Cancer of Thyroid & Other Endocrine Glands	1	537.9	1	220.2	1	115.6	1	95.1	2	180.5
Cancer of Bone	1	235.3	2	356.0	1	92.7	6	465.6 **	0	---
Cancer of All Lymphatic, Haematopoietic Tissue	3	56.2	12	118.7	20	104.9	35	125.7	43	110.9
Lymphosarcoma & Reticulosarcoma	0	---	1	42.9	3	69.0	3	57.1	2	36.0
Hodgkins Disease	0	---	4	191.1	4	158.2	4	182.8	2	101.0
Leukemia & Aleukemia	3	120.2	5	117.3	8	100.9	17	145.7	19	106.3
Cancer of All Other Lymphopoietic Tissue	0	---	2	139.6	5	117.3	11	126.1	20	149.8

(continued)

Table 15 continued
Cause Specific SMRs for WHITE MALES Stratified by Years Since Hired

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 10 years		10–19 years		20–29 years		30–39 years		40+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
Benign Neoplasms/Neoplasms of Unspecified Nature	0	---	4	404.2 *	2	106.8	5	186.6	6	162.7
Diabetes Mellitus	1	44.4	4	71.3	8	65.3	25	129.6	32	105.6
Cerebrovascular Disease	4	64.5	20	94.9	45	78.2	88	88.0	192	89.1
All Heart Disease	29	66.6 *	140	87.6	328	81.2 **	620	101.7	909	99.7
Rheumatic Heart Disease	0	---	1	20.0	5	70.7	9	128.2	9	146.7
Ischemic Heart Disease	24	64.3 *	123	85.7	281	78.2 **	510	97.7	711	94.2
Chronic Endocard. Dis.; Other Myocard. Insuff.	0	---	3	166.4	8	176.1	9	65.1	3	7.9 **
Hypertension with Heart Disease	0	---	1	55.2	9	186.2	17	177.7 *	15	95.4
Hypertension w/o Heart Disease	1	235.5	2	150.1	2	76.5	7	195.8	12	187.4
Non–malignant Respiratory Disease	4	67.9	13	71.4	30	59.1 **	72	75.2 *	145	74.8 **
Influenza & Pneumonia	2	61.8	7	82.2	13	65.7	19	57.7 *	50	63.7 **
Bronchitis, Emphysema, Asthma	1	63.4	3	43.5	11	51.9 *	32	94.9	45	85.9
Bronchitis	0	---	0	---	2	52.9	6	101.5	11	119.6
Emphysema	0	---	3	63.3	9	56.2	24	92.0	32	76.4
Asthma	1	365.9	0	---	0	---	2	102.1	2	104.3
Ulcer of Stomach & Duodenum	1	84.2	0	---	0	---##	9	113.1	11	116.4
Cirrhosis of Liver	2	48.2	4	29.9 **	20	70.0	20	66.6	19	94.8
Nephritis & Nephrosis	2	102.4	4	123.2	7	138.1	6	89.8	10	79.9
All External Causes of Death	86	71.5 **	95	80.6 *	95	78.3 *	81	84.3	76	96.7
Accidents	58	73.0 *	72	97.4	61	79.6	59	95.6	45	80.5
Motor Vehicle Accidents	28	56.6 **	32	79.4	34	86.4	25	84.4	18	83.1
All Other Accidents	30	98.6	40	118.6	27	72.3	34	105.6	27	78.4
Suicides	9	52.8	10	45.6 **	29	110.3	18	79.3	30	175.2 **
Homicides & Other External Causes	19	116.8	13	91.3	5	39.8 *	4	47.8	1	25.5
All Other Causes of Death	11	56.0	34	79.6	77	80.9	126	82.3 *	272	100.8
Unknown Causes (In All Causes Category Only)	46		49		81		47		21	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL
SIGNIFICANT DEFICIT AT 1% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED.

Table 16
Cause Specific SMRs for NON-WHITE MALES Stratified by Years Since Hired
Port Arthur Refinery Update, 1937-1987
Expected Deaths Based on TEXAS DEATH RATES

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 10 years		10-19 years		20-29 years		30-39 years		40+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	46	44.1 **	109	58.0 **	211	63.1 **	374	81.2 *	602	96.5
Tuberculosis	3	285.5	2	83.5	3	97.4	2	72.1	1	43.1
All Malignant Neoplasms	2	26.9 *	15	65.7	54	90.4	92	90.9	132	99.6
Cancer of Buccal Cavity & Pharynx	0	---	0	---	1	45.0	3	103.2	3	123.3
Cancer of Digestive Organs & Peritoneum	0	---	3	38.3	21	106.8	23	75.8	39	104.6
Cancer of Esophagus	0	---	0	---	3	92.9	3	59.9	5	116.7
Cancer of Stomach	0	---	2	76.5	11	180.1	11	134.7	11	116.4
Cancer of Large Intestine	0	---	0	---	4	133.6	3	48.9	11	108.1
Cancer of Rectum	0	---	0	---	0	---	0	---	1	43.6
Cancer of Biliary Passages & Liver	0	---	0	---	1	67.8	0	---	2	58.3
Cancer of Pancreas	0	---	1	85.8	2	58.3	6	106.8	8	109.7
Cancer of Respiratory System	0	---	3	47.8	12	60.9	31	88.5	34	89.4
Cancer of Bronchus, Trachea, Lung	0	---	2	34.9	11	60.2	31	93.8	31	85.9
Cancer of Breast	0	---	0	---	0	---	1	686.6	0	---
All Uterine Cancers (Females only)	0	---	0	---	0	---	0	---	0	---
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---	0	---	0	---
Cancer of Other Female Genital Organs	0	---	0	---	0	---	0	---	0	---
Cancer of Prostate (Males only)	0	---	0	---	5	110.6	6	52.4	25	93.0
Cancer of Testes and Other Male Genital Organs	0	---	1	325.2	0	---	0	---	0	---
Cancer of Kidney	1	490.6	2	389.9	2	185.7	2	128.3	3	188.1
Cancer of Bladder and Other Urinary Organs	0	---	0	---	0	---	2	87.4	5	143.6
Malignant Melanoma of Skin	0	---	0	---	0	---	0	---	0	---
Cancer of Eye	0	---	0	---	0	---	0	---	0	---
Cancer of Central Nervous System	0	---	1	247.9	0	---	2	217.7	1	153.8
Cancer of Thyroid & Other Endocrine Glands	0	---	0	---	0	---	0	---	0	---
Cancer of Bone	0	---	0	---	0	---	1	248.0	1	258.3
Cancer of All Lymphatic, Haematopoietic Tissue	0	---	2	83.2	4	90.9	5	74.3	9	97.1
Lymphosarcoma & Reticulosarcoma	0	---	0	---	1	128.6	2	207.2	0	---
Hodgkins Disease	0	---	1	203.1	0	---	2	496.4	1	375.7
Leukemia & Aleukemia	0	---	1	113.7	0	---	1	40.4	2	55.5
Cancer of All Other Lymphopoietic Tissue	0	---	0	---	3	194.2	0	---	6	134.8

(continued)

Table 16 continued
Cause Specific SMRs for NON-WHITE MALES Stratified by Years Since Hired

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 10 years		10–19 years		20–29 years		30–39 years		40+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
Benign Neoplasms/Neoplasms of Unspecified Nature	0	---	0	---	1	121.1	3	337.2	3	285.3
Diabetes Mellitus	0	---	1	41.8	3	66.8	10	138.0	17	180.0 *
Cerebrovascular Disease	2	48.4	7	49.9	16	47.9 **	32	65.2 *	80	105.0
All Heart Disease	4	25.0 **	22	43.7 **	62	54.9 **	122	72.4 **	231	98.6
Rheumatic Heart Disease	0	---	0	---	4	242.8	0	---	3	228.6
Ischemic Heart Disease	1	10.1 **	16	45.4 **	44	51.8 **	82	67.7 **	154	95.6
Chronic Endocard. Dis.; Other Myocard. Insuff.	1	249.0	2	194.7	3	166.2	7	148.7	7	61.3
Hypertension with Heart Disease	0	---	2	65.0	3	54.1	12	143.1	12	111.3
Hypertension w/o Heart Disease	0	---	0	---	0	--- #	4	120.4	4	116.5
Non-malignant Respiratory Disease	3	75.0	6	65.5	12	71.2	18	75.6	32	86.2
Influenza & Pneumonia	2	85.9	2	34.8	8	80.8	10	78.3	13	65.0
Bronchitis, Emphysema, Asthma	0	---	3	137.2	2	47.3	2	37.2	2	31.7
Bronchitis	0	---	0	---	1	120.0	1	96.4	0	---
Emphysema	0	---	1	124.9	1	43.1	0	---	2	45.1
Asthma	0	---	2	262.0	0	---	1	112.4	0	---
Ulcer of Stomach & Duodenum	1	190.7	0	---	2	103.7	2	113.9	2	113.8
Cirrhosis of Liver	0	---	0	--- #	1	17.6 *	8	160.7	2	64.5
Nephritis & Nephrosis	1	72.9	2	73.4	2	46.0	5	101.8	11	161.9
All External Causes of Death	12	21.9 **	26	50.3 **	18	41.0 **	18	58.4 *	19	83.8
Accidents	5	22.0 **	17	70.8	13	54.2 *	12	62.0	12	71.0
Motor Vehicle Accidents	2	15.9 **	7	56.5	5	43.0	4	46.1	5	79.5
All Other Accidents	3	29.5 *	10	85.9	8	65.0	8	74.9	7	65.7
Suicides	1	42.6	2	103.0	2	123.0	0	---	4	308.9
Homicides & Other External Causes	6	21.9 **	7	30.6 **	3	18.4 **	6	66.0	3	72.6
All Other Causes of Death	10	95.5	9	43.3 **	16	40.7 **	36	63.0 **	61	69.2 **
Unknown Causes (In All Causes Category Only)	8		19		21		22		7	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL
# SIGNIFICANT DEFICIT AT 5% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED.

Table 17
Cause Specific SMRs for WHITE FEMALES Stratified by Years Since Hired
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 10 years		10–19 years		20–29 years		30–39 years		40+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	10	74.2	15	63.9	36	75.0	107	130.6 **	99	135.8 **
Tuberculosis	0	---	0	---	0	---	0	---	0	---
All Malignant Neoplasms	3	92.1	3	40.0	13	79.9	37	142.6 *	33	190.0 **
Cancer of Buccal Cavity & Pharynx	0	---	0	---	1	448.6	0	---	1	380.1
Cancer of Digestive Organs & Peritoneum	0	---	0	---	3	97.7	6	106.7	11	263.1 **
Cancer of Esophagus	0	---	0	---	0	---	0	---	1	643.0
Cancer of Stomach	0	---	0	---	0	---	2	284.2	0	---
Cancer of Large Intestine	0	---	0	---	2	169.3	2	86.5	5	278.7
Cancer of Rectum	0	---	0	---	1	414.2	0	---	2	795.0
Cancer of Biliary Passages & Liver	0	---	0	---	0	---	0	---	0	---
Cancer of Pancreas	0	---	0	---	0	---	2	159.7	2	197.1
Cancer of Respiratory System	1	581.7	0	---	0	---	9	178.6	5	140.7
Cancer of Bronchus, Trachea, Lung	1	658.3	0	---	0	---	9	184.2	5	144.3
Cancer of Breast	1	152.6	1	51.5	5	118.7	7	132.1	6	210.3
All Uterine Cancers (Females only)	0	---	1	77.3	0	---	3	194.0	3	362.5
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---	1	122.9	2	590.0
Cancer of Other Female Genital Organs	0	---	0	---	1	73.5	2	107.1	2	191.5
Cancer of Prostate (Males only)	0	---	0	---	0	---	0	---	0	---
Cancer of Testes and Other Male Genital Organs	0	---	0	---	0	---	0	---	0	---
Cancer of Kidney	0	---	0	---	0	---	1	235.1	2	595.6
Cancer of Bladder and Other Urinary Organs	1	7821.6 *	0	---	0	---	0	---	0	---
Malignant Melanoma of Skin	0	---	0	---	0	---	0	---	0	---
Cancer of Eye	0	---	0	---	0	---	0	---	0	---
Cancer of Central Nervous System	0	---	1	303.8	1	176.8	1	142.2	0	---
Cancer of Thyroid & Other Endocrine Glands	0	---	0	---	0	---	1	893.9	0	---
Cancer of Bone	0	---	0	---	0	---	1	1536.4	0	---
Cancer of All Lymphatic, Haematopoietic Tissue	0	---	0	---	0	---	4	186.4	1	62.3
Lymphosarcoma & Reticulosarcoma	0	---	0	---	0	---	1	260.9	0	---
Hodgkins Disease	0	---	0	---	0	---	0	---	0	---
Leukemia & Aleukemia	0	---	0	---	0	---	1	129.6	0	---
Cancer of All Other Lymphopoietic Tissue	0	---	0	---	0	---	2	226.8	1	135.7

(continued)

Table 17 continued
Cause Specific SMRs for WHITE FEMALES Stratified by Years Since Hired

CAUSE OF DEATH (ICDA 8th REVISION CODES)	< 10 years		10–19 years		20–29 years		30–39 years		40+ years	
	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR	Observed	SMR
Benign Neoplasms/Neoplasms of Unspecified Nature	1	1015.6	0	---	0	---	2	753.7	1	497.2
Diabetes Mellitus	0	---	0	---	1	82.4	2	89.7	3	162.6
Cerebrovascular Disease	0	---	1	65.0	3	79.0	6	85.2	6	77.8
All Heart Disease	0	---	2	56.1	6	56.3	22	89.4	34	128.9
Rheumatic Heart Disease	0	---	0	---	0	---	1	151.5	0	---
Ischemic Heart Disease	0	---	2	85.8	6	73.3	13	68.5	24	122.8
Chronic Endocard. Dis.; Other Myocard. Insuff.	0	---	0	---	0	---	0	---	1	51.6
Hypertension with Heart Disease	0	---	0	---	0	---	1	142.9	0	---
Hypertension w/o Heart Disease	0	---	0	---	0	---	0	---	0	---
Non–malignant Respiratory Disease	0	---	0	---	1	47.4	5	109.7	4	79.6
Influenza & Pneumonia	0	---	0	---	0	---	4	244.3	1	48.6
Bronchitis, Emphysema, Asthma	0	---	0	---	0	---	0	---	0	---
Bronchitis	0	---	0	---	0	---	0	---	0	---
Emphysema	0	---	0	---	0	---	0	---	0	---
Asthma	0	---	0	---	0	---	0	---	0	---
Ulcer of Stomach & Duodenum	0	---	0	---	0	---	0	---	0	---
Cirrhosis of Liver	0	---	0	---	0	---	3	164.1	0	---
Nephritis & Nephrosis	0	---	0	---	0	---	0	---	0	---
All External Causes of Death	4	92.0	5	115.1	4	81.0	5	129.2	2	105.7
Accidents	3	111.7	3	119.5	3	98.7	2	77.5	1	67.3
Motor Vehicle Accidents	2	100.3	3	182.1	2	109.4	2	156.5	0	---
All Other Accidents	1	138.5	0	---	1	82.0	0	---	1	102.9
Suicides	1	111.9	2	186.9	0	---	2	216.2	1	352.7
Homicides & Other External Causes	0	---	0	---	1	217.8	1	293.9	0	---
All Other Causes of Death	0	---	2	53.8	4	64.7	14	136.7	9	87.9
Unknown Causes (In All Causes Category Only)	2		2		4		11		7	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 18
Employment Characteristics for All Cohort Members
By Period of Hire
Port Arthur Refinery Update, 1937-1987

	< 1940 (n=5184)	1940-1945 (n=5029)	≥ 1945 (n=7631)
Person-Years (%)	178257.4 (33.9)	170389.4 (32.4)	177730.0 (33.8)
No. Deaths (%)	3827 (56.3)	2191 (32.2)	781 (11.6)
Percent Women	3.2	18.5	8.9
Employment Duration (yrs)			
Total Cohort			
Average	26.8	8.5	12.3
P_{50}	30.7	0.9	8.3
White Males			
Average	27.2	9.4	13.1
P_{50}	31.3	0.9	8.7
Non-White Males			
Average	27.8	10.5	12.6
P_{50}	31.1	1.7	9.9
White Females			
Average	13.5	3.7	6.5
P_{50}	8.1	0.6	3.9
Non-White Females			
Average	18.3	2.6	7.3
P_{50}	9.6	1.2	7.6
Interval Since Hire (yrs)			
Total Cohort			
Average	44.5	33.9	23.3
P_{50}	48.1	41.1	21.9
White Males			
Average	44.9	35.1	25.0
P_{50}	48.4	41.3	29.2
Non-White Males			
Average	43.6	32.9	19.3
P_{50}	46.9	39.6	16.1
White Females			
Average	39.1	30.5	20.1
P_{50}	48.6	42.4	17.3
Non-White Females			
Average	46.6	26.6	13.0
P_{50}	51.3	36.7	10.9

Table 19
Cause Specific SMRs for ALL COHORT MEMBERS by Period of Hire
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

Hired Before 01/01/1940 N=5,184 Hired Between 01/01/1940 & 12/31/1945 N=5,029 Hired After 12/31/1945 N=7,631

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Hired < 1940		Hired 1940–1945		Hired > 1945	
	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	3827	91.7 **	2191	101.6	781	77.7 **
Tuberculosis	21	90.6	10	90.7	2	44.2
All Malignant Neoplasms	791	103.9	505	106.6	186	88.9
Cancer of Buccal Cavity & Pharynx	18	83.2	11	83.6	7	113.9
Cancer of Digestive Organs & Peritoneum	218	102.9	114	99.6	45	99.1
Cancer of Esophagus	10	58.8	7	60.4	6	109.6
Cancer of Stomach	60	118.0	22	101.2	13	172.1
Cancer of Large Intestine	69	118.4	37	108.4	11	78.6
Cancer of Rectum	20	129.0	5	64.2	1	33.1
Cancer of Biliary Passages & Liver	8	50.5 *	4	37.5 *	1	22.0
Cancer of Pancreas	46	102.4	36	140.0	12	118.5
Cancer of Respiratory System	230	98.2	172	101.1	46	56.7 **
Cancer of Bronchus, Trachea, Lung	214	97.2	165	101.8	44	56.7 **
Cancer of Breast	5	133.4	12	115.2	5	147.7
All Uterine Cancers (Females only)	4	257.8	3	75.9	0	---
Cancer of Cervix Uteri (Females only)	3	340.9	0	---	0	---
Cancer of Other Female Genital Organs	2	187.9	3	89.7	0	---
Cancer of Prostate (Males only)	91	101.0	33	96.4	2	30.3
Cancer of Testes and Other Male Genital Organs	1	35.9	2	109.8	2	116.0
Cancer of Kidney	16	102.7	12	115.9	12	225.1 *
Cancer of Bladder and Other Urinary Organs	20	89.4	4	40.5	1	39.5
Malignant Melanoma of Skin	9	114.1	5	82.4	7	146.9
Cancer of Eye	2	298.7	0	---	0	---
Cancer of Central Nervous System	13	95.5	19	160.2	7	91.5
Cancer of Thyroid & Other Endocrine Glands	3	127.6	2	134.4	2	254.5
Cancer of Bone	8	225.3	3	167.5	2	218.7
Cancer of All Lymphatic, Haematopoietic Tissue	76	110.8	39	93.1	23	108.3
Lymphosarcoma & Reticulosarcoma	6	48.7	4	54.6	3	88.4
Hodgkins Disease	12	205.2 *	5	122.6	1	35.5
Leukemia & Aleukemia	32	105.2	15	88.6	10	117.7
Cancer of All Other Lymphopoietic Tissue	26	130.4	15	110.4	9	137.5
Benign Neoplasms/Neoplasms of Unspecified Nature	16	218.8 **	6	128.3	6	252.5
Diabetes Mellitus	73	127.5	26	84.0	8	61.7
Cerebrovascular Disease	358	87.5 *	110	73.2 **	34	83.1
All Heart Disease	1503	89.2 **	774	96.8	257	85.3 *
Rheumatic Heart Disease	22	118.0	8	65.3	2	34.2
Ischemic Heart Disease	1170	83.0 **	623	96.8	201	87.4
Chronic Endocard. Dis.; Other Myocard. Insuff.	38	81.7	4	15.9 **	2	20.4 **
Hypertension with Heart Disease	54	145.9 *	15	82.4	3	35.2
Hypertension w/o Heart Disease	28	147.9	3	36.6	1	36.7
Non–malignant Respiratory Disease	199	68.3 **	129	95.9	18	41.3 **
Influenza & Pneumonia	81	61.8 **	45	88.0	6	34.4 **
Bronchitis, Emphysema, Asthma	60	66.5 **	35	91.8	6	63.1
Bronchitis	14	84.3	6	93.5	1	68.1
Emphysema	41	60.6 **	26	91.5	5	77.4
Asthma	5	80.8	3	95.6	0	---
Ulcer of Stomach & Duodenum	21	90.2	7	68.5	0	---
Cirrhosis of Liver	31	61.5 **	32	76.7	16	53.8 **
Nephritis & Nephrosis	34	110.1	14	93.7	2	34.6
All External Causes of Death	206	70.4 **	194	85.4 *	147	61.4 **
Accidents	147	77.4 **	115	82.2 *	105	76.1 **
Motor Vehicle Accidents	66	73.6 *	51	70.7 *	52	66.8 **
All Other Accidents	81	80.7	64	93.9	53	87.5
Suicides	45	97.0	45	125.0	21	58.6 *
Homicides & Other External Causes	14	35.9 **	34	85.4	21	35.6 **
All Other Causes of Death	414	85.6 **	193	80.0 **	77	71.2 **
Unknown Causes (In All Causes Category Only)	132		188		27	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 20
Cause Specific SMRs for WHITE MALES by Period of Hire
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

Hired Before 01/01/1940 N=3,959 Hired Between 01/01/1940 & 12/31/1945 N=3,243 Hired After 12/31/1945 N=5,406

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Hired < 1940		Hired 1940–1945		Hired > 1945	
	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	2948	93.9 **	1640	109.3 **	592	81.7 **
Tuberculosis	14	85.3	6	87.6	2	72.3
All Malignant Neoplasms	608	106.2	356	110.8	132	87.1
Cancer of Buccal Cavity & Pharynx	12	69.3	10	104.9	5	118.3
Cancer of Digestive Organs & Peritoneum	163	107.1	78	104.5	30	95.4
Cancer of Esophagus	6	57.1	4	64.3	1	35.4
Cancer of Stomach	39	119.0	10	76.7	9	180.0
Cancer of Large Intestine	52	115.2	28	118.9	10	96.1
Cancer of Rectum	19	164.6	3	55.8	0	---
Cancer of Biliary Passages & Liver	6	52.2	3	44.8	1	33.7
Cancer of Pancreas	37	107.9	28	156.6 *	8	106.7
Cancer of Respiratory System	191	102.0	126	100.6	35	57.7 **
Cancer of Bronchus, Trachea, Lung	178	101.0	120	100.5	35	60.1 **
Cancer of Breast	0	---	0	---	0	---
All Uterine Cancers (Females only)	0	---	0	---	0	---
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---
Cancer of Other Female Genital Organs	0	---	0	---	0	---
Cancer of Prostate (Males only)	64	106.6	25	112.6	1	22.0
Cancer of Testes and Other Male Genital Organs	1	53.1	2	150.0	1	65.4
Cancer of Kidney	12	93.2	7	88.1	8	183.7
Cancer of Bladder and Other Urinary Organs	14	80.8	3	41.9	0	---
Malignant Melanoma of Skin	9	123.2	5	96.8	7	157.5
Cancer of Eye	2	332.4	0	---	0	---
Cancer of Central Nervous System	11	90.3	14	148.6	7	108.0
Cancer of Thyroid & Other Endocrine Glands	3	150.9	2	187.4	1	164.3
Cancer of Bone	6	221.9	2	161.6	2	301.4
Cancer of All Lymphatic, Haematopoietic Tissue	63	115.9	31	102.8	19	114.5
Lymphosarcoma & Reticulosarcoma	5	49.1	2	36.3	2	72.2
Hodgkins Disease	8	165.1	5	164.6	1	43.4
Leukemia & Aleukemia	29	115.7	15	119.4	8	121.3
Cancer of All Other Lymphopoietic Tissue	21	147.5	9	99.2	8	162.2
Benign Neoplasms/Neoplasms of Unspecified Nature	12	229.9 *	2	67.7	3	180.0
Diabetes Mellitus	48	116.4	16	81.4	6	68.0
Cerebrovascular Disease	253	89.2	72	78.4 *	24	96.6
All Heart Disease	1204	91.9 **	616	104.3	206	90.1
Rheumatic Heart Disease	16	108.3	6	70.3	2	47.0
Ischemic Heart Disease	973	85.7 **	509	102.1	167	91.0
Chronic Endocard. Dis.; Other Myocard. Insuff.	22	63.9 *	1	5.8 **	0	--- ##
Hypertension with Heart Disease	31	156.8 *	9	106.6	2	47.6
Hypertension w/o Heart Disease	21	212.1 **	2	58.9	1	94.8
Non–malignant Respiratory Disease	156	66.7 **	95	95.5	13	42.0 **
Influenza & Pneumonia	57	58.4 **	30	87.8	4	35.8 *
Bronchitis, Emphysema, Asthma	57	73.1 *	30	98.0	5	69.6
Bronchitis	13	91.7	6	116.8	0	---
Emphysema	40	66.2 **	23	95.8	5	93.9
Asthma	4	96.7	1	61.0	0	---
Ulcer of Stomach & Duodenum	17	90.6	4	53.9	0	---
Cirrhosis of Liver	26	62.0 *	23	73.9	16	69.2
Nephritis & Nephrosis	20	110.1	8	100.1	1	30.2
All External Causes of Death	163	77.1 **	154	101.1	116	68.1 **
Accidents	115	81.0 *	95	95.8	85	79.8 *
Motor Vehicle Accidents	52	76.4	45	87.6	40	65.7 **
All Other Accidents	63	85.0	50	104.1	45	98.0
Suicides	40	93.6	38	123.0	18	57.2 *
Homicides & Other External Causes	8	57.5	21	146.1	13	48.0 **
All Other Causes of Death	324	93.5	146	91.7	50	66.9 **
Unknown Causes (In All Causes Category Only)	82		140		22	

* SIGNIFICANT AT 5%. LEVEL; ** SIGNIFICANT AT 1% LEVEL
SIGNIFICANT DEFICIT AT 1% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED

Table 21
Cause Specific SMRs for NON-WHITE MALES by Period of Hire
Port Arthur Refinery Update, 1937-1987
Expected Deaths Based on TEXAS DEATH RATES

Hired Before 01/01/1940 N = 1,045 Hired Between 01/01/1940 & 12/31/1945 N = 821 Hired After 12/31/1945 N = 1,381

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Hired < 1940		Hired 1940-1945		Hired > 1945	
	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	805	83.3 **	399	78.7 **	138	58.2 **
Tuberculosis	7	107.0	4	113.8	0	---
All Malignant Neoplasms	163	94.0	98	92.4	34	76.9
Cancer of Buccal Cavity & Pharynx	5	122.1	1	33.9	1	57.3
Cancer of Digestive Organs & Peritoneum	50	90.2	26	85.1	10	86.1
Cancer of Esophagus	3	47.4	3	60.4	5	196.5
Cancer of Stomach	21	120.2	12	162.0	2	90.9
Cancer of Large Intestine	14	121.8	4	58.6	0	---
Cancer of Rectum	1	27.3	0	---	0	---
Cancer of Biliary Passages & Liver	2	50.2	1	33.5	0	---
Cancer of Pancreas	8	81.7	6	103.0	3	139.3
Cancer of Respiratory System	38	84.3	35	94.2	7	38.4 **
Cancer of Bronchus, Trachea, Lung	35	83.2	34	96.9	6	34.7 **
Cancer of Breast	0	---	1	645.3	0	---
All Uterine Cancers (Females only)	0	---	0	---	0	---
Cancer of Cervix Uteri (Females only)	0	---	0	---	0	---
Cancer of Other Female Genital Organs	0	---	0	---	0	---
Cancer of Prostate (Males only)	27	89.6	8	66.5	1	48.5
Cancer of Testes and Other Male Genital Organs	0	---	0	---	1	516.1
Cancer of Kidney	3	121.9	4	234.7	3	384.1
Cancer of Bladder and Other Urinary Organs	6	124.5	0	---	1	169.8
Malignant Melanoma of Skin	0	---	0	---	0	---
Cancer of Eye	0	---	0	---	0	---
Cancer of Central Nervous System	2	183.0	2	191.9	0	---
Cancer of Thyroid & Other Endocrine Glands	0	---	0	---	0	---
Cancer of Bone	2	255.8	0	---	0	---
Cancer of All Lymphatic, Haematopoietic Tissue	13	101.5	4	51.3	3	86.8
Lymphosarcoma & Reticulosarcoma	1	53.4	1	91.4	1	235.2
Hodgkins Disease	4	445.1 *	0	---	0	---
Leukemia & Aleukemia	3	62.6	0	---	1	71.5
Cancer of All Other Lymphopoietic Tissue	5	95.5	3	95.4	1	80.0
Benign Neoplasms/Neoplasms of Unspecified Nature	3	160.8	3	274.4	1	194.8
Diabetes Mellitus	21	148.9	9	121.2	1	32.1
Cerebrovascular Disease	98	83.7	30	64.5 *	9	67.7
All Heart Disease	281	80.3 **	117	69.3 **	43	67.7 **
Rheumatic Heart Disease	6	180.3	1	48.5	0	---
Ischemic Heart Disease	184	72.0 **	83	71.4 **	30	74.4
Chronic Endocard. Dis.; Other Myocard. Insuff.	16	146.1	2	33.1	2	84.6
Hypertension with Heart Disease	23	140.1	5	59.1	1	25.4
Hypertension w/o Heart Disease	7	80.2	1	22.9	0	---
Non-malignant Respiratory Disease	40	74.6	27	100.7	4	37.9 *
Influenza & Pneumonia	22	69.8	12	87.0	1	18.3
Bronchitis, Emphysema, Asthma	3	26.0 **	5	88.6	1	54.3
Bronchitis	1	43.5	0	---	1	445.7
Emphysema	1	14.5 *	3	91.7	0	---
Asthma	1	51.6	2	172.3	0	---
Ulcer of Stomach & Duodenum	4	93.4	3	130.8	0	---
Cirrhosis of Liver	5	65.7	6	86.2	0	--- ##
Nephritis & Nephrosis	14	115.0	6	102.9	1	46.7
All External Causes of Death	37	47.4 **	31	49.3 **	25	39.6 **
Accidents	28	61.3 **	16	48.0 **	15	53.5 *
Motor Vehicle Accidents	11	53.5 *	3	18.4 **	9	61.2
All Other Accidents	17	67.8	13	76.3	6	44.9 *
Suicides	3	94.4	4	167.0	2	66.6
Homicides & Other External Causes	6	24.2 **	11	45.4 **	8	26.0 **
All Other Causes of Death	84	65.9 **	30	48.9 **	18	66.9
Unknown Causes (In All Causes Category Only)	41		34		2	

* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL
SIGNIFICANT DEFICIT AT 1% LEVEL. OBSERVED DEATHS = 0, SMR NOT CALCULATED

Table 22
Cause Specific SMRs for WHITE FEMALES by Period of Hire
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

Hired Before 01/01/1940 N= 166 Hired Between 01/01/1940 & 12/31/1945 N= 932 Hired After 12/31/1945 N= 680

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Hired < 1940		Hired 1940–1945		Hired > 1945		
	Observed	SMR	Observed	SMR	Observed	SMR	
All Causes of Death	72	120.2	148	103.3	47	128.3	
Tuberculosis	0	---	0	---	0	---	
All Malignant Neoplasms	20	146.2	50	112.0	19	158.0	
Cancer of Buccal Cavity & Pharynx	1	519.9	0	---	1	646.3	
Cancer of Digestive Organs & Peritoneum	5	139.5	10	112.2	5	242.4	
Cancer of Esophagus	1	817.2	0	---	0	---	
Cancer of Stomach	0	---	0	---	2	659.2	
Cancer of Large Intestine	3	206.0	5	138.2	1	118.9	
Cancer of Rectum	0	---	2	319.9	1	699.0	
Cancer of Biliary Passages & Liver	0	---	0	---	0	---	
Cancer of Pancreas	1	135.2	2	103.6	1	233.9	
Cancer of Respiratory System	1	59.2	11	145.2	3	146.7	
Cancer of Bronchus, Trachea, Lung	1	61.9	11	149.9	3	151.1	
Cancer of Breast	5	201.7	10	103.8	5	175.8	
All Uterine Cancers (Females only)	4	316.8	3	81.3	0	---	
Cancer of Cervix Uteri (Females only)	3	414.2	0	---	0	---	
Cancer of Other Female Genital Organs	2	207.9	3	92.4	0	---	
Cancer of Prostate (Males only)	0	---	0	---	0	---	
Cancer of Testes and Other Male Genital Organs	0	---	0	---	0	---	
Cancer of Kidney	1	449.4	1	146.1	1	574.2	
Cancer of Bladder and Other Urinary Organs	0	---	1	284.1	0	---	
Malignant Melanoma of Skin	0	---	0	---	0	---	
Cancer of Eye	0	---	0	---	0	---	
Cancer of Central Nervous System	0	---	3	217.3	0	---	
Cancer of Thyroid & Other Endocrine Glands	0	---	0	---	1	1712.9	
Cancer of Bone	0	---	1	648.4	0	---	
Cancer of All Lymphatic, Haematopoietic Tissue	0	---	4	104.3	1	93.4	
Lymphosarcoma & Reticulosarcoma	0	---	1	141.2	0	---	
Hodgkins Disease	0	---	0	---	0	---	
Leukemia & Aleukemia	0	---	0	---	1	224.1	
Cancer of All Other Lymphopoietic Tissue	0	---	3	226.9	0	---	
Benign Neoplasms/Neoplasms of Unspecified Nature	1	530.0	1	168.8	2	1176.9	*
Diabetes Mellitus	4	260.8	1	27.8	1	118.5	
Cerebrovascular Disease	7	96.1	8	71.9	1	44.8	
All Heart Disease	17	81.6	39	102.3	8	105.9	
Rheumatic Heart Disease	0	---	1	63.2	0	---	
Ischemic Heart Disease	12	73.3	29	103.3	4	76.5	
Chronic Endocard. Dis.; Other Myocard. Insuff.	0	---	1	51.7	0	---	
Hypertension with Heart Disease	0	---	1	89.5	0	---	
Hypertension w/o Heart Disease	0	---	0	---	0	---	
Non–malignant Respiratory Disease	2	59.2	7	88.2	1	54.7	
Influenza & Pneumonia	1	55.5	3	97.7	1	142.5	
Bronchitis, Emphysema, Asthma	0	---	0	---	0	---	
Bronchitis	0	---	0	---	0	---	
Emphysema	0	---	0	---	0	---	
Asthma	0	---	0	---	0	---	
Ulcer of Stomach & Duodenum	0	---	0	---	0	---	
Cirrhosis of Liver	0	---	3	85.8	0	---	
Nephritis & Nephrosis	0	---	0	---	0	---	
All External Causes of Death	6	210.9	9	78.4	5	98.6	
Accidents	4	195.4	4	55.2	4	133.1	
Motor Vehicle Accidents	3	300.3	3	69.7	3	152.4	
All Other Accidents	1	94.4	1	33.4	1	95.0	
Suicides	2	416.0	3	111.7	1	77.9	
Homicides & Other External Causes	0	---	2	192.8	0	---	
All Other Causes of Death	6	72.7	16	81.3	7	133.0	
Unknown Causes (In All Causes Category Only)	9		14		3		

* SIGNIFICANT AT 5%. LEVEL; ** SIGNIFICANT AT 1% LEVEL

Table 23

Distribution of Hourly and Salaried Workers
All Cohort Members
Port Arthur Refinery Update, 1937-1987

Percent Time Salaried	No. Employees (%)		No. Deaths (%)	
0 (=100% Hourly)	14691	(82.3)	5926	(87.2)
25	316	(1.8)	147	(2.2)
50	298	(1.7)	144	(2.1)
75	207	(1.2)	92	(1.4)
90	271	(1.5)	109	(1.6)
100	1991	(11.2)	346	(5.1)
Unknown	70	(0.4)	35	(0.5)

Table 24
Cause Specific SMRs for ALL COHORT MEMBERS by Pay Status+
Port Arthur Refinery Update, 1937–1987
Expected Deaths Based on TEXAS DEATH RATES

Hourly N=14,691 25–75% Salaried N=821 90–100% Salaried N=2,262

CAUSE OF DEATH (ICDA 8th REVISION CODES)	Hourly		25–75% Salaried		90–100% Salaried	
	Observed	SMR	Observed	SMR	Observed	SMR
All Causes of Death	5926	96.5 **	383	76.4 **	455	71.7 **
Tuberculosis	32	97.0	0	---	1	34.1
All Malignant Neoplasms	1284	106.3 *	87	88.4	101	79.4 *
Cancer of Buccal Cavity & Pharynx	30	87.0	3	104.8	3	89.9
Cancer of Digestive Organs & Peritoneum	323	103.3	24	96.3	30	96.5
Cancer of Esophagus	22	75.1	1	49.0	0	---
Cancer of Stomach	84	123.2	5	99.3	6	98.5
Cancer of Large Intestine	98	111.0	11	147.0	8	81.4
Cancer of Rectum	19	86.2	4	220.7	3	133.5
Cancer of Biliary Passages & Liver	12	46.0 **	0	---	1	37.5
Cancer of Pancreas	79	116.6	3	53.3	12	176.2
Cancer of Respiratory System	404	98.8	20	58.4 *	20	50.5 **
Cancer of Bronchus, Trachea, Lung	381	98.4	19	58.6 *	19	50.4 **
Cancer of Breast	14	116.2	0	---	8	161.5
All Uterine Cancers (Females only)	5	118.0	1	694.6	1	43.7
Cancer of Cervix Uteri (Females only)	1	37.6	1	1151.3	1	70.2
Cancer of Other Female Genital Organs	5	140.0	0	---	0	---
Cancer of Prostate (Males only)	104	93.4	8	89.6	8	89.0
Cancer of Testes and Other Male Genital Organs	5	93.3	0	---	0	---
Cancer of Kidney	36	138.1	3	133.1	1	36.2
Cancer of Bladder and Other Urinary Organs	22	75.2	2	78.7	1	37.0
Malignant Melanoma of Skin	18	118.1	0	---	3	146.8
Cancer of Eye	1	116.6	1	1241.8	0	---
Cancer of Central Nervous System	33	120.8	3	129.0	3	89.5
Cancer of Thyroid & Other Endocrine Glands	6	157.4	0	---	1	214.7
Cancer of Bone	12	228.7 *	0	---	1	183.6
Cancer of All Lymphatic, Haematopoietic Tissue	115	104.9	9	98.1	14	116.3
Lymphosarcoma & Reticulosarcoma	7	36.5 **	3	183.7	3	144.3
Hodgkins Disease	14	131.8	1	117.3	3	248.1
Leukemia & Aleukemia	51	110.0	2	50.0	4	77.8
Cancer of All Other Lymphopoietic Tissue	43	128.4	3	111.5	4	111.0
Benign Neoplasms/Neoplasms of Unspecified Nature	19	158.8	4	433.1 *	5	365.8 *
Diabetes Mellitus	91	108.1	7	104.3	8	84.3
Cerebrovascular Disease	431	85.7 **	37	92.8	30	59.0 **
All Heart Disease	2188	93.9 **	148	74.3 **	186	80.0 **
Rheumatic Heart Disease	27	88.2	2	80.8	3	87.3
Ischemic Heart Disease	1704	89.3 **	119	71.0 **	163	85.6 *
Chronic Endocard. Dis.; Other Myocard. Insuff.	41	60.9 **	2	33.2	1	13.5 *
Hypertension with Heart Disease	66	121.6	2	56.4	4	77.9
Hypertension w/o Heart Disease	21	81.5	2	126.3	8	375.7 **
Non–malignant Respiratory Disease	311	79.4 **	19	54.7 **	15	38.1 **
Influenza & Pneumonia	113	67.7 **	8	57.4	10	59.0
Bronchitis, Emphysema, Asthma	93	80.6 *	6	56.2	2	18.2 **
Bronchitis	19	92.8	2	105.5	0	---
Emphysema	68	79.4	2	24.4 *	2	24.6 *
Asthma	6	66.1	2	308.2	0	---
Ulcer of Stomach & Duodenum	23	73.8	4	150.7	1	33.8
Cirrhosis of Liver	68	67.0 **	5	61.0	6	51.5
Nephritis & Nephrosis	48	109.4	2	65.5	0	--- #
All External Causes of Death	492	77.1 **	23	52.3 **	30	41.2 **
Accidents	324	82.6 **	18	63.5	23	51.5 **
Motor Vehicle Accidents	153	76.3 **	7	49.1	9	38.1 **
All Other Accidents	171	88.9	11	77.8	14	66.1
Suicides	101	103.8	4	50.0	6	48.0
Homicides & Other External Causes	67	56.4 **	1	18.6	1	7.8 **
All Other Causes of Death	587	84.3 **	38	68.3 *	55	74.6 *
Unknown Causes (In All Causes Category Only)	331		7		9	

+ See text for definition of pay status.
* SIGNIFICANT AT 5%, LEVEL; ** SIGNIFICANT AT 1% LEVEL
# SIGNIFICANT DEFICIT AT 5% LEVEL. OBSERVED DEATHS=0, SMR NOT CALCULATED.

Table 25
Lymphatic and Hematopoietic Tissue Cancers by Cell Type
All Males
Port Arthur Refinery Update, 1937-1987

	Observed Deaths	Expected Deaths[1]	SMR	(95% Confidence Limits)
AML (205.0)[2]	10	15.945	62.7	(30.1 - 115.3)
CML (205.1)	6	7.113	84.4	(31.0 - 183.6)
ALL (204.0)	8	3.082	259.6*	(112.1 - 511.5)
CLL (204.1)	3	10.044	29.9*	(6.2 - 87.3)
NHL (200,202)	30	42.233	71.0	(47.9 - 101.4)
MM (203)	19	19.390	98.0	(59.0 - 153.0)

1 = Expected number of deaths based on rates for white males regardless of race (from Selvin et al., 1983)
2 = Numbers in parentheses are codes for the International Classification of Diseases (ICD), 8th Revision
* = $p < 0.05$

Abbreviations:
AML = Acute Myeloid Leukemia
CML = Chronic Myeloid Leukemia
ALL = Acute Lymphatic Leukemia
CLL = Chronic Lymphatic Leukemia
NHL = Non-Hodgkin's Lymphoma
MM = Multiple Myeloma

Table 26
Selected Characteristics of Decedents[1] with
Underlying Cause of Death Due to Acute Lymphatic Leukemia
Port Arthur Refinery Update, 1937-1987

ID	Year of Hire	Age at Hire	Year Employ't Terminated	Years Worked	Year of Death	Age at Death	Interval Since Hire
A	1910	32	1940	29.5	1940	62	29.5
B	1924	29	1959	34.8	1972	77	47.6
C	1936	22	1957	20.9	1957	43	20.9
D	1943	54	1954	11.1	1962	72	19.0
E	1944	43	1944	0.5	1983	82	39.2
F	1945	62	1956	10.7	1956	73	10.7
G	1949	27	1975	26.7	1975	53	26.7
H	1953	22	1957	4.0	1961	30	8.4

[1] All decedents were white males

Note: Seven of the eight ALL deaths occurred in Texas. Employees A, C, D, F, and G died in Jefferson County. Employees B and E died in Taylor and Nacogodoches counties, respectively. Employee H died in San Diego, California.

Table 27

Length of Employment Trend Analysis for Deaths Due to Acute Lymphatic Leukemia
Port Arthur Refinery Update, 1937-1987

	Employment Duration Strata (yrs)		
	< 10	10-19	20+
Avg Employment Duration (yrs)	2.5	14.4	33.0
Observed Deaths	2	2	4
Expected Deaths	1.25	0.39	1.45
SMR	160.0	512.8	275.9
SMR 95% CI	19.4-578.0	62.1-1652.5	75.2-706.3

Chi square (trend): 0.23, p= 0.6333

TRIAGE of 8(e) Submissions

Date sent to triage: _____ (NON-CAP) CAP

Submission number: 12032C TSCA Inventory: Y N (D)

STUDY TYPE (circle appropriate):

Cheng-Chun Lee (E609C)
ATOX SBTOX SEN w/NEUR

Larry Newsome (E425)
ECO AQUATO

Katherine Anitole (E611G)
RTOX/DTOX

Daljit Sawhney (E611A)
CTOX STOX

Deborah Norris (E602)
NEUR

Jeff Beaubier (E608)
(EPI)

Ron Ward (E611F)
IMMUNO/ALLERG

David Lai (E611B)
CARC

Michael Cimino (E611D)
GTOX

Leonard Keifer (E611C)
META/PHARM

NOTES:

CECATS\TRIAGE TRACKING DBASE ENTRY FORM

CECATS DATA:
Submission # 8EHQ- 1194 - 12032 SEQ. 5

TYPE: INT SUPP FLWP

SUBMITTER NAME: Chevron Corporation

INFORMATION REQUESTED: FLWP DATE:
0501 NO INFO REQUESTED
0502 INFO REQUESTED (TECH)
0503 INFO REQUESTED (VOL. ACTIONS)
0504 INFO REQUESTED (REPORTING RATIONALE)

DISPOSITION:
0699 REFER TO CHEMICAL SCREENING
0678 CAP NOTICE

VOLUNTARY ACTIONS
0401 NO ACTION NECESSARY
0402 STUDIES PLANNED/UNDERWAY
0403 NOTIFICATION OF INTERESTED PARTIES
0404 LABELING CHANGES
0405 PROCESS/HANDLING CHANGES
0406 APP/USE DISCONTINUED
0407 PRODUCTION DISCONTINUED
0408 CONFIDENTIAL

SUB. DATE: 10/27/94 OUT DATE: 11/02/94 CSRAD DATE: 11/14/94

CHEMICAL NAME: Petroleum Refining Process

CAS# None

INFORMATION TYPE:		P F C
0201	ONCO (HUMAN)	01 02 04
0202	ONCO (ANIMAL)	01 02 04
0203	CELL TRANS (IN VITRO)	01 02 04
0204	MUTA (IN VITRO)	01 02 04
0205	MUTA (IN VIVO)	01 02 04
0206	REPRO/TERATO (HUMAN)	01 02 04
0207	REPRO/TERATO (ANIMAL)	01 02 04
0208	NEURO (HUMAN)	01 02 04
0209	NEURO (ANIMAL)	01 02 04
0210	ACUTE TOX. (HUMAN)	01 02 04
0211	CHR. TOX. (HUMAN)	01 02 04
0212	ACUTE TOX. (ANIMAL)	01 02 04
0213	SUB ACUTE TOX (ANIMAL)	01 02 04
0214	SUB CHRONIC TOX (ANIMAL)	01 02 04
0215	CHRONIC TOX (ANIMAL)	01 02 04

INFORMATION TYPE:		P F C
0216	EPI/CLIN	01 02 04
0217	HUMAN EXPOS (PROD CONTAM)	01 02 04
0218	HUMAN EXPOS (ACCIDENTAL)	01 02 04
0219	HUMAN EXPOS (MONITORING)	01 02 04
0220	ECO/AQUA TOX	01 02 04
0221	ENV. OCCC/REL/FATE	01 02 04
0222	EMER INCI OF ENV CONTAM	01 02 04
0223	RESPONSE REQEST DELAY	01 02 04
0224	PROD/COMP/CHEM ID	01 02 04
0225	REPORTING RATIONALE	01 02 04
0226	CONFIDENTIAL	01 02 04
0227	ALLERG (HUMAN)	01 02 04
0228	ALLERG (ANIMAL)	01 02 04
0239	METAB/PHARMACO (ANIMAL)	01 02 04
0240	METAB/PHARMACO (HUMAN)	01 02 04

INFORMATION TYPE:		P F C
0241	IMMUNO (ANIMAL)	01 02 04
0242	IMMUNO (HUMAN)	01 02 04
0243	CHEM/PHYS PROP	01 02 04
0244	CLASTO (IN VITRO)	01 02 04
0245	CLASTO (ANIMAL)	01 02 04
0246	CLASTO (HUMAN)	01 02 04
0247	DNA DAM/REPAIR	01 02 04
0248	PROD/USE/PROC	01 02 04
0251	MSDS	01 02 04
0299	OTHER	01 02 04

TRIAGE DATA:	NON-CBI INVENTORY	ONGOING REVIEW	SPECIES	TOXICOLOGICAL CONCERN:	USE:	PRODUCTION:
	YES	YES (DROP/REFER)	HMN	LOW		
CAS SR	NO	NO (CONTINUE)		MED		
	IN TRIAGE	REFER		HIGH		

COMMENTS: Non-Cap, SS

EQMS Ratings on 8(E) Submissions--Non-Cap -12188A--Mar. 30, 1994

8E Number and Chemical Name	Rank	Reason or Brief Description
12188 PVC, Synthetic resins	High	A nested case-control epidemiologic study of chemical workers who died of pancreatic cancer, and 5:1 matched controls, following up a cohort mortality study in the same plant, showed a significant association between duration of exposure to vinyl and polyethylene, and the cancers. Surrogate measures of exposure were work time since assigned to, and duration in, a major production work area. Vinyl chloride has been implicated in liver cancer induction but is not well known for other cancer effects.